MAY

THE JOURNAL OF THE AMERICAN DENTAL ASSOCIATION

Dental Caries—*Bunting*
Mouth Pathology—*Downs*
Enamel of Permanent Teeth—*Swanson*
Prosthesis—*House*
Tooth Conformation—*Bruening*
Anesthetic Agents—*Rounds*
Enamel Hypoplasia in Rickets—*Klein*
Postoperative Care—*Hume*
Economic Aspects of Dentistry—*Ryan*
Cast Gold Alloys—*Shell*
Calcium Products—*Rice*
Paradentosis (Pyorrhea)—*Becks*
Vincent's Infection—*Daley*
Cast Gold Inlay—*Hart*
Full Denture Procedure—*McNeely*
Caries and Systemic Pyorrhea—*Hawkins*

EDITORIAL
Council on Dental Therapeutics

DENTAL HEALTH EDUCATION
Children's Teeth—*Gerlach*
Diet and Calcium Metabolism—*Parmelee*

CONTENTS

De Los L. Hill, D.D.S. ..... Frontispiece

ORIGINAL COMMUNICATIONS

A Review of Recent Researches on Dental Caries.
By Russell W. Bunting, D.D.S. 785

Laboratory Studies in Mouth Pathology.
By William G. Downs, Jr., D.D.S., Ph.D. 806

Age-Incidence of Lines of Retzius in the Enamel of Human Permanent Teeth.
By John H. Swanson 819

Studies in Prosthesis.
By M. M. House, D.D.S., F.A.C.D. 827

Tooth Conformation and Position in Operative Dentistry.
By E. H. Bruening, D.D.S. 852

Basic Principles Controlling the Selection and Adaptability of Anesthetic Agents in Oral Operations.
By Frank W. Rounds, D.D.S., F.A.C.D. 857

Etiology of Enamel Hypoplasia in Rickets as Determined by Studies on Rats and Swine.
By Henry Klein, D.D.S., Sc.D. 866

Postoperative Care of Surgical Procedures About the Mouth.
By E. C. Hume, D.D.S., F.A.C.D. 885

The Economic Aspects of Preventive Dentistry.
By Edward J. Ryan, B.S., D.D.S. 896

Cast Gold Alloys: Their Physical Properties and Dental Application.
By John S. Shell, B.S. 904

Calcium Products in Dentistry.
By W. S. Rice, D.D.S. 916

What Factors Determine the Early Stage of Paradentosis (Pyorrhea).
By Hermann Becks, M.D., D.D.S. 922

Dangers of Operative or Surgical Work in Presence of Vincent's Infection.
By Francis H. Daley, D.M.D. 931

The Cast Gold Inlay.
By E. R. Hart, D.D.S. 933

Current Delusions in Full Denture Procedure.
By Charles M. McNeely, D.D.S. 938

What Is the Cause of Caries and Systemic Pyorrhea?
By Harold F. Hawkins, D.D.S. 943

EDITORIAL DEPARTMENT

The Council on Dental Therapeutics 946

BUREAU OF DENTAL HEALTH EDUCATION

Technical Procedures in the Operative Care of Children's Teeth.
By Elsie Gerlach, D.D.S. 950

The Physician's Viewpoint on Diet in Relation to Calcium Metabolism.
By A. H. Parmelee, M.D. 959

CURRENT LITERATURE

Extracts and Abstracts 964

MISCELLANY

Book Reviews 967
Revised Prohibition Regulations 968
Correspondence 969
News 970

Association News 971

Announcements 972

ADVERTISEMENTS

Index to Advertisements A-59
Classified Section A-53, A-54

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Original Communications

A REVIEW OF RECENT RESEARCHES ON DENTAL CARIES*

By RUSSELL W. BUNTING, D.D.S., Ann Arbor, Mich.

AT no period in history has there been so much interest shown in the problem of dental caries as at the present time. Never before has this disease been the object of so much scientific research as is now being directed toward it. During the past ten years, reports of investigations on this subject by a wide variety of research workers have occupied a prominent place in dental and medical literature. These reports have aroused a keen interest in this study, not only in the professions, but also among the laity. The lay press has given considerable prominence to many research reports on dental caries; a clear indication that the subject makes a strong appeal to the public mind.

In the course of the development of this study, several different schools of thought have arisen, and many of the statements which have appeared are widely divergent and conflicting. It is inevitable in the study of so complex a problem that such differences should appear. As a result of these widely different points of view, attacks are being made upon the problem from various angles, which may ultimately prove to be very fruitful. Eventually, error must fall before truth and, by a process of elimination, those principles which are true will be distinguished from the false.

At the present time, there is considerable confusion in the minds of those who are attempting to follow the development of these studies. It is difficult for many to analyze and to evaluate the various statements which are being made and to distinguish between established fact and hypothetical opinion. In view of this situation, it has been suggested that a re-

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*Read before the Section on Biologic Sciences and Research at the Midwinter Clinic of the Chicago Dental Society, Feb. 4, 1931.

view of the recent work on the subject might be of value. In this review, the salient points of the various researches should be stated and correlated. It is with this object in view that this paper has been undertaken.

The principal works of the following are to be considered: May Mellanby, of Sheffield, England; Percy R. Howe, of Boston, Mass.; C. J. Grieves and E. V. McCollum, of Baltimore, Md.; Sherman L. Davis, formerly of Indianapolis, Ind.; J. D. Boyd and C. L. Drain of Iowa City, Iowa; M. T. Hanke, of Chicago, Ill.; Harold F. Hawkins, of Los Angeles, Calif.; Martha R. Jones, of Hawaii, and the Michigan group at Ann Arbor. These have been selected because of the apparent importance of the laboratory or clinical studies which they have reported. The work of other investigators in this field will be referred to in somewhat less detail.

It is not the intention to make a critical analysis of all of the publications of these contributors, some of which are quite voluminous, but rather to state briefly the most important findings and the general point of view and conclusions of each worker, and to call attention to certain correlations or contradictions which may exist between them.

MAY MELLANBY

Mrs. Mellanby, while working with her husband in a study of the effects of feeding rachitic diets to litters of growing puppies, noticed that certain abnormalities appeared in the teeth and in their supporting structures.[1] These dogs were fed on a basal diet of separated milk, white bread, orange juice, sodium chlorid, yeast and lean meat. When this basal diet was supplemented by cod liver oil, whole milk and butter fat or egg yolk, the teeth and jaws developed normally and their structure was of apparently good quality. When this basal diet was supplemented by linseed oil, lard, sugar, rice, oatmeal or white of egg, the following dental defects were noticed:

1. Comparatively soft and poorly developed jaws and alveolar processes in which osteoid tissue often took the place of bone.

2. Teeth, chiefly lower incisors, were crowded together.

3. A delay in the time of eruption and a slowing of the rate of eruption of the teeth.

4. A delay in the rate of calcification of enamel which, when formed, was to a greater or less extent, defective.

5. Deficient dentin containing numerous interglobular spaces.

6. Light teeth as compared to their size with a lower calcium content.

7. The greater the rate of growth the greater the defects when factor X (fat-soluble vitamin) was deficient, that is, the defects produced were specific and not comparable to those of acute illness.

8. Diminished power of resistance to diseases such as distemper.

Mrs. Mellanby, in describing these hypoplastic changes in the dental structure and noting the similarity of the white areas which appeared on the teeth to dental caries in the early stages, has raised the question of their relationship to the process of dental decay. She has assumed that such dental defects produced in dogs by deficient diets may be correlated with defective dental conditions (dental hypoplasia and caries), which are prevalent among children. During the past ten years, she has carried on extensive investigations in which she has fed experimental diets to litters of dogs and has published her findings, illustrated by excellent photographs of histologic sections of the teeth and jaws.

1. Mellanby, May: Diet and Teeth, Brit. J. Dent. Sc., 64:70-81 (March 1) 1921.

She states[2] that, when dogs are fed a basal diet well fortified by fat-soluble food factors, the teeth and bones are of good quality, but that when fat soluble vitamins are inadequate in amount, disturbances in dentition, an irregular arrangement of the teeth, defects of the enamel and a low calcium content of the teeth are produced.

Of 302 deciduous human teeth studied she found only 3 per cent showing macroscopic defects, but on sectioning these teeth and making a histologic examination, it was found that 84.5 per cent were hypoplastic. Of these hypoplastic teeth, 83.8 per cent were carious. These observations she presented in answer to the statement that deciduous teeth were usually better formed than permanent teeth but that they decayed faster.

(Since these 302 teeth were taken from 218 children and since they were probably extracted because of extensive caries, the question may be asked: How about the unextracted teeth in the same mouths? Were they not also hypoplastic and were they equally prone to caries?)

Mrs. Mellanby concludes:

> There is a direct relationship between the structure of the teeth and caries; those badly formed having greater susceptibility, those well formed being more immune to the disease. . . . The structure of human teeth is probably controlled by dietetic factors in the same way as shown experimentally in the case of dogs. . . . Food, after digestion and absorption, by regulating the structure of the teeth, influences the incidence of caries.

She mentions the possibility of changes in the saliva producing increased resistance of the tooth to bacteriologic invasion, but seems to be rather skeptical concerning the importance of the latter factor. She emphatically states that the bacteriologic factor in caries is comparatively unimportant when the teeth are well formed and that it is only significant when teeth are badly formed or irregularly arranged in the jaws.

Mrs. Mellanby holds the opinion that certain cereals in the diet have a specific inhibiting effect on calcium metabolism and therefore on tooth formation. She states[3] that oatmeal and wheat germ contain a "toxamin" which, when fed during the developmental period, antagonizes calcification of the teeth unless the diet is highly fortified by fat-soluble vitamins.

(Steenbock and his associates[4] report a series of animal experimentations in which they have fed various high cereal diets to several hundreds of rats and eighty-three dogs and state that it is impossible to demonstrate that rolled oats possesses any specially rickets producing qualities. On the contrary, it is somewhat less significant in this respect than maize, but somewhat more so than wheat.)

In a study of the histologic changes in the teeth of dogs fed on good and poor diets, Mrs. Mellanby found that[5]: 1. Good diets during the formative period produce good enamel and good primary dentin. 2. After formation, teeth that are free from dental caries have a good grade of secondary dentin, teeth that are carious have a poor grade of secondary dentin

2. Mellanby, May: Experimental Study of the Influence of Diet on Tooth Formation, Dent. Rec., 39:22-28 (Jan. 1) 1919; Experimental Evidence Demonstrating Influence of Special Dietetic Factor on Development of the Teeth and Jaws, ibid., 40:63-75 (Feb. 2) 1920.

3. Mellanby, May: Effect of Diet on Structure of Teeth, Brit. Dent. J., 44:1031-1041 (Sept. 15) 1923.

4. Steenbock, Harry; Black, A., and Thomas B. H.: Cereals and Rickets, J. Ind. & Eng. Chem., 19:907, 1927.

5. Mellanby, May: Effect of Diet on Resistance of Teeth to Caries, Proc. Roy. Soc. Med. (Sect. Odontol.), 16:74-82 (Oct.) 1923.

and the status of these secondary dentins is dependent on the character of the diet subsequent to the period of primary dentition.

She reports[6] that the action of ultraviolet light on dogs fed on experimental diets is similar to that of cod liver oil added to the diet, and the unfavorable symptoms which usually result from diets deficient in antirachitic vitamin were decreased.

During recent years, Mrs. Mellanby and her associates have conducted dietary experiments on children for the control of dental caries. The first of these which she reports[7] includes observations on thirty-two children who were fed on three types of diets, one of which was fortified with calcium and vitamin D bearing foods, the other two being less well fortified and containing oatmeal. She reports that the initiation and spread of dental caries was appreciably less with the fortified diet than with those that were less favorable. She later reports[8] experiments which include observations on seventy-one children divided into three dietetic groups as follows: (1) diets of high calcium content and containing cod liver oil; (2) diets containing less calcium and phosphorus, no cod liver oil, considerable oatmeal and sodium bicarbonate, and (3) diets containing one-half the amount of cod liver oil and milk as used in the first diet.

The degree of caries per child which developed in nine months was as follows: Group 1, 2.05; Group 2, 6.66; Group 3, 4.03. From this, she concludes that the resistance of erupted and calcified teeth of children to caries can be influenced by certain constituents of food.

(It is interesting to note that the diet which was fed to Group 2, in which the largest amount of caries occurred, contained sodium bicarbonate and had the highest alkaline ash, while the other two were slightly acid-forming. Mrs. Mellanby makes no reference to the factor of acid-base balance.)

As an example of the influence of dental hypoplasia on caries, Mrs. Mellanby cites[9] a statistical study of 1,036 deciduous human teeth, of which 40 per cent were well calcified, and 73 per cent of these were caries-free. Among the 60 per cent that were hypoplastic, only 15 per cent were caries-free. She concludes that the degree of caries is directly proportional to structural defects. She states that about 11 per cent of the total number of teeth did not show this correlation. This discrepancy she attributes to the presence or absence of secondary dentin, but she states that even poorly formed teeth may become resistant if secondary dentin is of a good order.

(In a discussion of the behavior of dental caries in hard and soft teeth, it should be borne in mind that the underlying factors of metabolism which produce either good or poor teeth may continue to be active and may modify other factors which are involved in the process.)

In her later studies, Mrs. Mellanby has come to the conclusion that resistance of teeth to caries can be influenced by diet independently of the original structure of

6. Mellanby, May: Influence of Light in Relation to Diet on Formation of Teeth, Brit. Dent. J., 45:545-552 (May 1) 1924.

7. Mellanby, May; Pattison, C. L., and Proud, J. W.: Effect of Diet on the Development and Extension of Caries in Teeth of Children, Brit. Med. J., 2:354-355 (Aug. 30) 1924.

8. Mellanby, May: Some Factors of Diet Influencing Spread of Caries in Children, Brit. Dent. J., 47:1045-1057 (Oct. 1) 1926.

9. Mellanby, May: Structure of Human Teeth in Relation to Caries, Brit. Dent. J., 48:1481-1493 (Dec. 15) 1927.

the tooth. She stresses the importance of vitamin D on calcification and the anti-calcifying properties of cereals. She recommends

1. That children be given diets which have been shown to produce perfectly formed teeth during the actual calcifying process.
2. The continuing of the diet along similar lines after the teeth are calcified.

She believes that vitamin D is a much more important factor in the calcifying of the teeth than vitamin C, and disagrees with those who are at present placing a great deal of importance on the latter food factor.

She reports the results obtained from feeding twenty-one children on institutional diets[10] to which varying amounts of irradiated ergosterol were added. In this group, she found that the occurrence of caries per child was 1.1 per cent, which is somewhat less than that observed in a former experiment[7] with cod liver oil, in which 2.2 per cent was the lowest recorded rate.

In 1929, Mrs. Mellanby published the first volume of a comprehensive work entitled "Diet and the Teeth. An Experimental Study," which was printed in His Majesty's stationery office. In this volume, she has discussed the dental structure in dogs as it relates to various dietary experimental procedures. This work embodies her former contributions and constitutes a valuable addition to the study of dental disease.

A more brief and yet comprehensive statement of the entire scope of her investigations was given in 1929 before the International Dental Congress in Washington, to which students of the subject are referred.[11]

Comment. — Mrs. Mellanby's work constitutes a noteworthy contribution to our knowledge of the effect of normal and deficient diets on the structure of dental and alveolar tissues. Her attack on the problem has been keenly scientific, but practically all her investigations have been directed with one particular end in view; namely, to prove that the activity of dental caries is controlled by the quality of the tooth. The nature of resistance to caries she vaguely describes as being due to two factors: (1) the initial structure of the tooth and (2) the character of the secondary dentin.

She does not attempt to explain how the character of the secondary dentin on the interior of the tooth influences the initial stage of dental caries, which is generally conceded to be located on the enamel surface. Her point of view is distinctly opposed to the opinion of many keen observers in dentistry who believe that imperfect structure may alter the rate of caries, but that it does not necessarily induce it. In fact, a great mass of evidence may be presented to show that teeth having the poorest structure may be wholly unaffected by dental caries. That this fact can be accounted for by the character of secondary dentin formed on the inside of the tooth, as Mrs. Mellanby states, still remains to be proved.

Mrs. Mellanby has reported no studies of the bacteriologic factor involved in dental caries, nor does she attach any importance to the variability of aciduric types of organisms as they are related to the progress of the disease. She categor-

10. Mellanby, May, and Pattison, C. L.: Action of Vitamin D in Preventing Spread and Promoting Arrest of Caries in Children, Brit. Med. J., 2:1079-1082 (Dec. 15) 1928.

11. Mellanby, May: Experiments on Dogs, Rabbits and Rats and Investigations on Man Which Indicate Power of Certain Food Factors to Prevent and Control Dental Disease, J. A. D. A., 17:1456-1480 (Aug.) 1930.

ically relegates them to a place of minor importance and refuses to consider them seriously. This attitude is not in accord with the findings of certain other workers in this field of study.

Although Mrs. Mellanby has produced a wide variety of hypoplastic changes in the teeth of dogs and has discussed them as being related to the problem of dental caries, she has never reported the occurrence of any actual carious lesions in the teeth of dogs under experimental observation. In view of the fact that caries-like lesions have been experimentally produced in other animals at will through deficient diets, the absence of these lesions in Mrs. Mellanby's dogs is significant. It is probable that, because of the typical conical shape of the dog's teeth, the forces of mastication prevented stagnation of food substances on all the exposed surfaces of the teeth. Consequently, although the forces for dental caries may have been present in the mouths of these dogs, the environment of these teeth was not conducive to the occurrence of that disease. To this factor, Mrs. Mellanby gives little or no consideration.

PERCY R. HOWE

Throughout his connection with the Forsyth Dental Infirmary in Boston, Dr. Howe has been actively engaged in the study of the problem of dental caries. In 1917, Howe and Hatch[12] studied the bacteria associated with dental caries and came to the conclusion that the Moro-Tissier group of micro-organisms constitute the dominating flora of dental caries, and that "they possess in a greater degree than any other organism, the attributes considered necessary for at least the inauguration of dental caries."

Shortly thereafter, Howe became interested in dietary experiments on animals in which he followed the work of Zilva and Wells of England, who had noted hypoplastic changes in the teeth of guinea-pigs, which were fed scorbutic diets. By means of a diet consisting of fat-free milk and rolled oats fed to guinea-pigs over a considerable period of time, Howe produced the first experimental caries of the teeth. When he corrected the diet by the administration of orange juice, he noted an arrest of caries. Later, when the orange juice was withheld, a new period of decay was inaugurated. This, the first concrete evidence that dental caries is intimately associated with or produced by dietary deficiencies, opened an entirely new field of thought in the study of this problem.

Howe states that the feeding of sugar to these animals had no appreciable effect; that if the diet were adequate, high sugar content might cause the oral flora to become highly aciduric in character, but caries did not occur.[13]

Dr. Howe defends the use of guinea-pigs in his experimentation,[14] claiming that they are preferable to the dog or the rat because the dog and rat are not so sensitive to variations in vitamin C deficiency as are guinea-pigs, monkeys and man. He describes and illustrates a wide variety of abnormalities in the teeth and disturbances in the skeleton and bony articulations produced in guinea-pigs by vitamin C-deficient diets. He disagrees with Mrs. Mellanby as to the importance of vitamin D and states that, in his opinion, vitamin C deficiencies produce a more pronounced effect on the teeth.

12. Howe, P. R., and Hatch, Ruth E.: Study of Micro-Organisms of Dental Caries, Dent. Cosmos, 59:961-973 (Oct.) 1917.

13. Howe, P. R.: Dental Caries, Dent. Cosmos, 62:921-929 (Aug.) 1920.

14. Howe, P R..: Report on Studies of Effect of Vitamin-Deficient Diets upon Teeth, Dent. Cosmos, 63:1086-1092 (Nov.) 1921.

More recently, Dr. Howe has performed extensive feeding experiments with monkeys on the assumption that these animals are more truly related to man than is any other type of animal. He fed diets in which calcium and vitamins C and D requirements were varied and found that many dental disorders and definite caries-like lesions in the teeth were produced.

In discussing his observations, he says that the whole problem is exceedingly complex, and that no one constituent of the diet may be considered by itself alone, but only in relation to the other component parts of the diet as a whole. He states[15]: "At the present stage of our work, we are inclined to regard the amount of calcium and phosphorus, the amount of antiscorbutic factor and of protein, the amount of indigestible residue in the food, as subjects of especial importance in dental disorders."

Howe reports that scorbutic diets affect the supporting tissues so that the cells are unable to produce and maintain intercellular substances, and that these changes are most marked in the matrix of the bone and dentin. In the pulps of the teeth, odontoblasts undergo atrophic changes and shrink away from the dentin. Diets deficient in vitamin A seem to produce a specific effect on the secretory epithelium, making the functional cells nonsecretory. During the process of tooth development, enamel-forming cells cease to function when vitamin A is withheld. They shrink or atrophy or are replaced by stratified nonkeratonized epithelium.

Howe has prepared some beautiful sections of teeth[16] in which changes in the dentin have occurred under scorbutic diet, and later, after the diet was corrected, an attempt at repair was apparent. He believes that this is satisfactory evidence of a circulation in the dentin and that calcium may be drawn out of the dentin and harmful substances substituted under conditions of nutritional instability. This theory is offered as a reasonable explanation of the periodic occurrence of dental caries and its appearance in pregnancy and lactation or during protracted illness.

(Howe does not explain the mechanism by which these changes in the dentin affect the initial lesion of caries, which necessarily involves the periphery of the enamel.)

For the prevention of dental caries through dietary means, Howe recommends[17] that the diet contain a liberal amount of fresh natural foods which contain minerals and vitamins. He specifies 1 pint of milk daily, which, he says, supplies sufficient calcium for the needs of the individual. He stresses the importance of vitamin C, which is found in all fresh raw foods and fruits, especially in leafy vegetables. As a protection against a possible deficiency in that regard, he recommends the ingestion of 1 pint of orange juice daily.

Comment. — The researches of Dr. Howe are outstanding contributions to our knowledge of the relationship of nutrition to the development of the teeth and maxillary structures. He has clearly shown that not only the structure but also the arrangement of the teeth and the alveolar process may be seriously disturbed

15. Howe, P. R.: Studies of Dietary Disorders Following Experimental Feeding with Monkeys, J. A. D. A., 11:1149-1160 (Dec.) 1924.

16. Howe, P. R., New Research on Dental Caries, Dent. Cosmos, 68:1021-1033 (Nov.) 1926.

17. Howe, P. R.: Practical Nutritional Suggestions for Dentists, J. A. D. A., 17:2140-2143 (Nov.) 1930.

by dietary deficiencies and that, in the same manner, the disease which we know as dental caries may be inaugurated. Dr. Howe stresses the importance of calcium metabolism in both the formative functions and in the resistance of the teeth to dental caries, and accentuates the importance of vitamin C in that regard over that of all other factors. He does not explain the mechanism by which calcium metabolism influences dental caries other than to say that when calcium metabolism is normal, the resistance of the tooth to dental caries is increased.

This resistance of the tooth to caries, Howe describes in terms of dentin changes, which he believes are directly dependent on calcium metabolism. He, like Mellanby, gives little attention to the changes in enamel under variations in calcium metabolism and fails to explain the manner in which the character of the primary and the secondary dentin influences the early stages of dental caries on the periphery of the enamel. He states, as does Mellanby, that the environmental bacterial factors involved in dental caries are purely incidental and secondary to the resistance of the tooth attacked. These deductions are largely inferred and are not substantiated by adequate experimental proof.

C. J. GRIEVES AND E. V. MCCOLLUM

In the study of the problem of dental caries, Clarence J. Grieves undertook a critical survey of the hundreds of rat skulls and skeletons which were filed in the laboratories of E. V. McCollum in Baltimore. These rats had been fed on various forms of deficient diets. A large group of rats were also carried on diets specifically intended to produce dental caries. The observations which he and McCollum made in those early days of dietary study are most significant. They call attention[18] to the borderline status of the average American diet in the light of the newer concepts of nutrition and state that variations either way in such borderline diets may be very significant. It is their opinion that many phases of dietary deficiency may not be clinically apparent other than in that the teeth and supporting structures may be affected.

They object to the use of guinea-pigs for nutritional studies as they relate to the teeth of man, and defend the use of the rat for that purpose. They state that rats fed on an adequate diet had no dental caries and that the most caries in rats occurred when they were fed on diets deficient in calcium, protein, and vitamins A and D. They did not find that any one of these constituents was more important than any other, but rather that the relative proportion of calcium, phosphorus and vitamins A and D had a most important bearing on dental development and dental disease.

(It must be remembered that the rat is not subject to scurvy. These deductions drawn from dietary experiments on rats are therefore open to question in regard to the significance of the vitamin C factor.)

Grieves discusses the possibility of endocrine disturbance[19] as a possible factor in caries susceptibility, but he questions its importance on the ground that it is possible to produce by alterations in the diet the dental lesions that Erdheim produced by the removal of the parathyroid gland.

He also discusses the relative impor-

18. Grieves, C. J.: Preliminary Study of Gross Maxillary and Dental Defects in 300 Rats on Defective and Deficient Diets, J. A. D. A., 9:467-497 (June) 1922.

19. Grieves, Clarence J.: The Effect of Defective Diets on Teeth, J. A. D. A., 10:573-582 (July) 1923.

tance of vitamin C, saying that scurvy as evidence of vitamin C deficiency is relatively and actually rare among the American people, whereas the vitamin D deficiencies are much more apparent. He makes another significant statement to the effect that, in his opinion, hypoplastic teeth are not more susceptible to caries than are normal teeth.

Comment.—The writings of Clarence J. Grieves reveal a truly scientific attack on the subject in question. His analysis of the problem is most clear. He does not disparage or attempt to overthrow the millerian hypothesis as others have done, but he has attempted to correlate the newer knowledge of nutrition to other observations which are very generally accepted as facts. It is indeed unfortunate that his illness and untimely death terminated these brilliant studies, which were but well begun.

SHERMAN L. DAVIS

During the past several years, Dr. Davis has appeared on lecture platforms of medical and dental societies and before lay audiences in many parts of this country, speaking on the subject of foods and the general principles of nutrition. More recently, he has devoted himself to the specific problem of dental caries and the means of controlling that disease through diet.

Although his public appearances have been very extensive, his scientific publications in this special field are very limited. He discusses the general problem of calcium metabolism as related to the bones and teeth, placing special emphasis on the importance of vitamins C and D, but presents few data.

In his earlier papers,[20] he recommends the fortification of the diet with 2 oranges a day; in summer, vitamin D to be provided by butter and carrots; in winter, by 2 teaspoons of cod liver oil. In addition, he recommends the drinking of 1 quart of milk daily. He forbids the use of candy, especially chocolate, to children who have dental caries. He also reduces the amount of cereals in the diet.

His nutritional program for the arrest of caries[21] calls for 1 compound calcium tablet before breakfast and supper; 1 teaspoon of silver lactate after breakfast and supper; whole wheat bread; whole wheat or bran cereal; the juice of 2 oranges daily, other raw fruits in season; no candy and very little pastry; 5 ounces of meat daily; potatoes once a day; from a pint to a quart of milk daily, and a liberal helping of leafy vegetables or salad at least once daily.

He claims to have noted an improvement in dental conditions following the adoption of such a diet. He later recommends the adoption of certain proprietary preparations which he has formulated and the manufacture of which he sponsors.[22] These preparations contain iron, calcium, phosphorus, parathyroid extract and vitamins A, D and E, and are dispensed under the trade names of Syrup of Alfemine, Caperoid tablets, Vicodol and Vicaperol capsules. These he recommends to be taken in addition to a general diet somewhat similar to the one outlined above.

He has published a number of testimonials submitted by dentists who have observed patients under such treatment. These testimonials report a very remarkable improvement in the dental conditions of the patients so treated.

20. Davis, S. L.: Nutrition, Dent. Digest, 35:527-533 (Aug.) 1929.

21. Davis, S. L.: Nutritional Procedure for Arresting of Caries, Proc. A. A. Dent. Schools, 1929, pp. 300-301.

22. Davis, S. L.: Dental Caries, Pacific Dent. Gaz., 38:584-595 (Sept.) 1930.

Comment.—In THE JOURNAL, there has appeared a report[23] of the Council on Dental Therapeutics in which it is stated that, as the outcome of many inquiries as to the activities of Sherman L. Davis and his qualifications to speak on the subject of dental caries, a survey has been made and an attempt to evaluate his work. The nature of the proprietary preparations which he recommends is discussed and the statement is made that the Council has been unable to determine the exact composition of these preparations other than that they were said to contain iron, phosphorus, calcium, parathyroid extract and vitamins, A, D and E. The Council questions the ability of these products to produce the specific effects for which they are recommended and suggests that before their adoption, more scientific data be obtained in support of the claims made for them.

A review of Dr. Davis' work[24] has also been made in *The Journal of the American Medical Association,* in which it is stated that the administration of such preparations is a most unusual procedure in relation to the practice of either scientific medicine or dentistry.

In view of the fact that the diet which Dr. Davis recommends is, in itself, so nearly adequate to the needs of the average individual, it is difficult to determine whether the beneficial effects reported were produced by the additional preparations or by the diet. In the light of other reported successes in caries control through dietary regulation without special medication, this question becomes very apparent. Consequently, the rationale of the recommendations of Dr. Davis and the advisability of administering his preparations for the control of dental caries have not been substantiated by adequate scientific evidence. This does not apply to his dietary recommendations, which seemingly conform to generally accepted principles of nutrition, and which, if adopted, might exert a beneficial effect on dental health without the special accessory preparations.

J. L. BOYD AND C. L. DRAIN

In the course of repeated routine examinations of patients in a dental clinic in Iowa City, C. L. Drain noticed an apparent arrest of caries among a number of children who were under observation. In these children, twenty-eight in number, open cavities which existed in the mouth did not increase in size and the walls of the cavities became dark and hard in character. This change could not be related in any way to an improvement in mouth hygiene, for many mouths were notably unclean.

When, with the aid of J. D. Boyd,[25] the medical histories of these children were investigated, it was found that, without exception, those who had arrested caries were diabetic children who had been under medical control for a period of six months or more. The diets which these children had received consisted mainly of milk, butter, eggs, meat, cod liver oil, bulky vegetables and fruits and 1 quart of milk daily. Although most of the children were receiving insulin, Boyd and Drain state that the insulin played no part in the arrest of caries other than to balance the metabolism. They attribute the caries control to a hardening of the

23. Sherman L. Davis Treatment: Caperoid, Vicodol, Syrup of Alfemine, Coun. Dent. Therap., J. A. D. A., 17:1744 (Sept.) 1930.

24. Syrup of Alfemine, etc.: Sherman L. Davis Preparations and Propaganda, Bur. Investigation, J. A. M. A., 94:1163 (April 12) 1930.

25. Boyd, J. D., and Drain, C. L.: Arrest of Dental Caries in Childhood, J. A. M. A., 90:1867-1869 (June 9) 1928.

tooth produced by the correction of nutritional faults and the provision of adequate vitamin and mineral salt intake.

To determine whether or not insulin played any part in the process, they report[26] the feeding of four nondiabetic children with a typical diabetic diet for a period of four months. During this time, they observed no advance of open cavities in the mouth, but rather a hardening of their peripheral walls. After the suspension of the diabetic diet and the resumption of ordinary rations, two of these children were found to be suffering from recurrent active caries.

They also report dietetic experiments on children in private homes. Five children were placed on a prescribed diet consisting of 1 quart of milk, 1 egg, 1 teaspoon of cod liver oil, 1 ounce of butter, 1 orange, one or more servings of succulent vegetables or fruits and candy after meals but at no other times, together with such other food as might seem desirable. The children thrived on this diet, and dental caries appeared to be arrested within a period of ten weeks.

Another report is made on four girls who were suffering from celiac disease. The diet of these girls was similar to the one outlined above except that they were allowed more sugar and simple carbohydrates, with double the amount of protein and no fat. Children carried on this diet for four years showed no new cavities in their teeth and the old unfilled cavities became hard.

Boyd and Drain state that there was no change in the p_H of the saliva or in the acid potential of oral bacteria of individuals who have been carried on such experiments. Furthermore, there was no change in the oral hygiene, for many of the mouths were very unclean. They believe that the improved dental conditions were dependent not on any one factor but rather on the proper balance of all food factors. They call attention to the fact that these results were obtained entirely by dietary measures and that no mineral supplements or therapeutic food accessories were employed.

Comment. — These feeding experiments carried on by the group in Iowa are most interesting and constitute a valuable link in the chain of dietary experimental evidence as related to dental caries. Irrespective of the concept which they hold as to the exact mechanism by which the results have been obtained, the fact remains that under the administration of nutritionally sound diets, an arrest of dental caries was noticed by trained dental observers.

These observations are somewhat unique in that this group reports an arrest of caries in a much shorter time than others have observed. In fact, it is a question in the minds of many whether one can determine, within the space of from two to four months, whether or not dental caries is actually being arrested. The error in observation, if there is one, would affect the results only to a degree, and unquestionably the observations made by this group clearly show a definite restraining influence on the activity of dental caries in children who were carried on a definitely weighed and balanced nutritional program. The fact that many of these children were suffering from serious systemic and metabolic diseases makes these observations even more remarkable.

HAROLD F. HAWKINS

In a survey of a group of students in the Dental School of the University of Southern California, Harold F. Hawkins and his associates made certain observa-

26. Boyd, J. D.; Drain, C. L., and Nelson, M. V.: Dietary Control of Dental Caries, Am. J. Dis. Child., 38-721-725 (Oct.) 1929.

tions concerning the relation of dental caries to other factors of general health and metabolism. They stress the correlation of caries to the ingestion of acid forming foods, especially in the form of bread and pastry and state that alkaline forming foods constitute a prime requisite in the prevention of dental decay.

They speak of dental caries as if it were synonymous with acidosis and describe the prevention of this disease in the terms of the creation of a strong alkaline reserve in the body and a highly alkaline saliva which will combine with the acids of localized fermentation in the mouth associated with dental caries. They believe that a high calcium content of the saliva is also inhibitive to dental caries through its ability to neutralize the acids of caries. They accentuate the importance of fat soluble vitamins A and D in the diet and believe them to be important factors in caries immunity, but they do not believe that vitamin C plays any important part in caries control.

They suggest a diet for the prevention of dental caries which is high in fruits, vegetables and milk, to maintain the calcium level of the body on a high plane and to increase the alkaline ash. They advise a low sugar and candy consumption, especially for children. Cod liver oil is also recommended during childhood.

In conclusion, they make this significant statement, which fairly well portrays their point of view of the problem, "Miller's theory may be expanded to express the indicated local and systemic factors thus: Dental decay is the molecular disintegration of the hard tissues of the teeth by unneutralized acids of fermentation due to a lack of basic or acid neutralizing salts in the saliva."

As a result of his survey, Hawkins states[27] that he has found that those who are immune to dental caries consume liberal amounts of foods which are high in alkaline ash, in calcium and in vitamin D bearing factors, and low in cereal products. Practically the reverse is true of those who are subject to active caries.

In a large series of salivary analyses, he reports that the composition of the saliva reflects the character of the food intake; those of the immune were either high in alkaline ash or high in calcium content, or both. The saliva of caries-susceptible individuals showed considerable acidity and low calcium content. He states that, in caries, the basal metabolism is above normal, while in those subject to pyorrhea, basal metabolism may not be increased unless there is toxic absorption. Hawkins and his group[28] carried on dietary experiments in which seventy-four children in an orphanage were fed on specific diets for fourteen months. These diets contained moderate amounts of meat and very little cereal and had a high alkaline ash and a high calcium content. Those children whose saliva was low in calcium and low in alkalis were fed cod liver oil and orange juice. He reports that, during the period of observation, no new cavities were found, and the gum tissues were healthy, but that a marked increase in the calculus deposits was noted. He concludes that caries and pyorrhea may be prevented in the absence of focal infection by suitable diets determined by coordinated tests on the saliva and the urine.

27. Hawkins, H. F.; Hendricks, W. W., and Hills, N. R.: Cause and Prevention of Dental Caries as Indicated by a Survey, J. A. D. A., 15:354-361 (Feb.) 1928.

28. Hawkins, Harold F.: Cause and Control of Caries and Pyorrhea, Proc. Pacific Coast Dent. Con., 1929, pp. 257-274.

In an attempt to explain the mechanism by which diet controls dental caries, Dr. Hawkins states[29] that, in immune mouths, the enamel of the teeth becomes more condensed because of the precipitation of calcium from the saliva into the interprismatic spaces. In the mouths of persons susceptible to caries, the interprismatic substance is much less dense because of the character of the salivary environment. He stresses the importance of the environmental factors of the tooth on the status of the tooth enamel. He thinks that the immunity to caries is directly proportional to the alkaline and calcium content of the saliva.

The salivary analyses by which he has accumulated a large number of his data have been made by use of the colorimetric method, the dependability of which he strongly defends, claiming that this method gives a better estimation of the true buffer value of the saliva than can be obtained by electrometric determinations.

Hawkins' theory of dental caries control is perhaps best stated in the summary which he makes at the conclusion of this paper:

1. Dental decay of the enamel is caused by the removal of the intercementing substance from between the enamel rods.

2. This removal is accomplished by acids produced by the fermentation of carbohydrate foods. (Miller's theory.)

3. Probably the only carbohydrate that can accomplish this removal is the cereal grains, because it is only in this class of starches that we find gluten, or a similar product which is insoluble in the normal saliva and which, being sticky, is able to hold the fermenting starch in direct contact with the teeth.

4. This acid of fermentation will remove the intercementing substance unless it is neutralized by the saliva.

5. Neutralization is accomplished first by the presence of the alkaline salts of the saliva and secondly by the calcium content. Either or both together are able to accomplish this neutralization.

Control of dental decay is accomplished

1. By removal of the food plaques in and about the teeth through the use of raw fruits, which have a physical and chemical action on the residue; and by careful tooth brushing.

2. By maintaining a high alkalinity of the saliva, in order to neutralize mouth acidity. This can be accomplished by the use of (a) a mixed diet rich in alkaline-forming foods (fruits, vegetables, milk and true nuts); (b) removing any source of focal infection such as diseased tonsils and infected teeth, the toxins of which interfere with acid salt elimination through the kidneys, compelling the removal of acids through the saliva, and (3) maintaining a very low cereal diet, as cereal grains of probably all types, when consumed in high concentration, have a toxic-like action on the kidneys, preventing acid elimination through this channel with a resulting acidity or reduced alkalinity of the saliva.

3. By maintaining as high a calcium content of the saliva as possible with a given alkalinity, giving consideration to the endocrine type of the individual. This is accomplished by (a) a generous intake of calcium foods (milk, cheese and leafy vegetables) and either sunbaths or a diet containing vitamin D to aid the calcium assimiliation, and (b) maintaining as acid a urine as possible consistent with a generous alkalinity of the saliva. The acid urine will conserve calcium loss through the kidneys.

Comment.—The writings of Dr. Hawkins reveal a somewhat different slant on the problem than has been expressed by any other workers. He recommends the adoption of practically the same dietary régime as other investigators in this field, but does not hold with them that immunity to dental caries is produced by a hardening of the tooth through changes in the calcium content of the pulpal circulation. Rather does he visualize the nutritional effects as operating to increase the neutralizing powers of the saliva through an increase of alkalinity

29. Hawkins, Harold F.: Dental Decay: What It Is and Means for Its Control, J. A. D. A., 16:781-795 (May) 1929.

and an increase of calcium, through which, in his opinion, the acids of caries may be neutralized as quickly as they are formed and thus their attack on the dental structure be prevented.

The theory on first thought sounds plausible, but it must be remembered in this connection that the saliva of all individuals, both the immune and the susceptible, possesses a buffer reaction which neutralizes the weak acids of caries if they come into actual contact with them. For this reason, the saliva of the susceptible as well as the immune would prevent dental caries, could it reach the spot where the acids are being formed. Apparently, this is not true, but rather does this process take place beneath an enveloping film or plaque which protects the acids of caries from dilution and neutralization by the saliva. Consequently, we are led to question the importance which Dr. Hawkins places on the changes in salivary p_H that may occur under normal conditions.

Furthermore, this hypothesis of Dr. Hawkins is based largely upon data obtained from large numbers of salivary analyses which have not been substantiated as yet by any other workers in this field. This is especially true in regard to the remarkable variations in calcium and p_H determinations which he reports. He goes to considerable length in justifying the use of the colorimetric method for the determination of the salivary p_H. He states that he allows the reagent to stand in the saliva one hour before making the reading. (This procedure is not in accord with generally accepted biochemical methods.) He says: "We believe that the p_H reading at the end of an hour is very near to the true neutralizing value of the saliva." He does not state what colorimetric method was used nor the manner of the collection of the saliva and determination of the p_H; whether under oil or in open tubes. Dr. Hawkins seems to commit himself to the belief that p_H values are measures of the alkaline reserve of body fluids.

Van Slyke[30] says: "The possible variations in the acid base balance of the blood may be stated as follows: The blood bicarbonate (alkaline reserve) may be high, low, or normal and in *each* of these conditions the p_H may be *high, low* or *normal.*" He also states that, though knowledge of the p_H of the other body fluids is limited, available knowledge indicates that they follow the same reaction laws.

Cummer (p. 236)[31] says:

> Two tests have been applied to the blood for the detection of acidosis:
>
> 1. Determination of the carbonate content of the whole blood or plasma—the so-called alkaline reserve (measured by the total CO_2 carrying power).
>
> 2. Determination of the hydrogen-ion concentration (p_H) of the blood. The latter merits little consideration because the results obtained by its use show little deviation from the normal except in moribund cases.

The former method, which will show all significant deviations from normal, measures the true neutralizing power of the body fluid in question and is the most important single determination. p_H values are only of biologic significance in conjunction with figures indicating total carbon dioxid carrying power.

Starr[32] has shown that many factors influence the p_H values of saliva.

30. VanSlyke, D. D.: Studies in Acidosis: XVII Normal and Abnormal Variations in Acid-Base Balance of Blood., J. Biol. Chem. 48:153 (Sept.) 1921.

31. Cummer, C. L.: Manual of Clinical Laboratory Methods: Philadelphia, Lea and Febiger, 1926, p. 236.

32. Starr, H. E.: Studies of Human Mixed Saliva, J. Biol. Chem., 54:43-54 (Sept.) 1922: Determination of the Hydrogen-Ion Concentration of Human Mixed Saliva, p. 43; Variations in Hydrogen-Ion Concentration of Human Mixed Saliva, p. 55.

It is evident that Dr. Hawkins and his co-workers are sincere in their desire to arrive at some equitable solution of the problem. The data which they have presented in support of their hypothesis are at variance with the findings of other workers in the field of biochemistry. These data, as well as the conclusions which are based upon them, must be verified by biochemical studies which are wholly acceptable to other scientific workers in the field of biochemistry before they may be established as facts.

MILTON T. HANKE

Milton T. Hanke, a biochemist, became interested in the study of dental caries through his association with a dental research group in Chicago. During this association, he made a dietary survey of 114 patients referred to him by the dentists comprising this group. He divided these patients into four groups, as follows: (1) those having no dental disorders; (2) those having dental caries; (3) those having caries and pyorrhea or gum inflammation, and (4) those having no caries, but having other pathologic conditions. He reports[33] that, in the first group, there were seventeen patients who were free from dental disorders, and of these, eleven were on a diet that contained ample vitamins, while five were slightly deficient in vitamins, and one, a boy aged 17 years, had a diet very deficient in vitamins, with poor health but excellent teeth.

In Group 2, there were forty-seven cases of active dental caries in which there was not one perfect diet. Twenty-seven had a diet with ample vitamin D intake, but were deficient in vitamin C. This, he states, is an indication that patients may have carious teeth even though they are ingesting adequate amounts of vitamin D. The entire group of carious individuals had a dietary deficiency of vitamin C.

In his analysis of dental caries, Dr. Hanke strongly disagrees with Dr. Miller's hypothesis, and unequivocally states that the initial stage of caries is not acid decalcification, but consists of an attack on the protein substances in the interprismatic cement of the enamel. He believes that bacteria are probably involved in the process, but that they act by virtue of proteolytic power rather than through their acid producing properties.

He reports[34] a statistical study of 191 cases under dietetic treatment and observation, and records improvement in the dental conditions of 104 as a result of the treatment. In this second group, a majority of those immune to caries had an ample vitamin D intake, while all those susceptible had a diet low in vitamin C; of whom, about 50 per cent had no other dietetic fault.

Although vitamin C deficiency is the most prominent feature of his report, Dr. Hanke says that this factor is not the most important one, but that he stresses the vitamin C intake because most diets are low in that respect. He recommends for the control of dental caries from 1 to 2 pints of milk, a moderate amount of meat, fresh vegetables, from a quarter to a half head of lettuce, the juice of one-half a lemon, 1 pint of orange juice and from 1 to 2 eggs and fresh fruits daily.

He justifies his use of such a large amount of orange juice[34] on the ground

33. Hanke, M. T.: Relation of Diet to Caries and Other Dental Disorders, J.A.D.A., 16:2263-2271 (Dec.) 1929.

34. Hanke, M. T.: Relation of Diet to General Health and Particularly to Inflammation of Oral Tissues and Dental Caries, J.A.D.A., 17:957-967 (June) 1930.

that Eddy[35] has found that 3 c.c. of orange juice is the optimal dose for guinea-pigs. From this, Hanke estimates that the optimal dose for a 150-pound man would be 450 c.c., or 1 pint.

Hanke reports that among 104 patients carried on this diet over a period of eight months, there were sixty in whom caries had been previously active who had no new cavities develop during the period of observation.

Comment. — It is interesting to note the attitude of an independent observer who has had no previous contact with the disease in question as a practitioner of either dentistry or medicine. In the statement of his first premise to the study, he takes issue with a fundamental principle which has been so well established that it has been considered an indubitable fact when he states that the primary lesion of caries is produced not by acids but by alkalis or proteolytic agents. Such statements are so contrary to a wealth of previous experience that they should not be taken seriously unless they are supported by more concrete evidence than that which is available at this time.

Dr. Hanke accentuates the importance of vitamin C and states that a deficiency of that particular food factor is the most prominent dietetic fault associated with dental caries. He recommends for the control of dental caries diets which include large amounts of citrous fruits and fresh vegetables, largely because of their high vitamin C content. In this opinion, he is supported by Percy R. Howe, but is opposed by May Mellanby, Clarence J. Grieves, Harold F. Hawkins and others.

In his discussion of the patients who have been carried on experimental diets in which there is a high vitamin C content, he attributes the beneficial effects solely to that factor, but fails to take into account many other corrections which his diet contains. In addition to vitamin C, the diet which he recommends contains much more calcium, alkaline ash and vitamin D than does the average American diet.

The data which he has thus far presented do not contain convincing evidence that the beneficial dental conditions which he reports have been solely or even largely due to vitamin C. Others have obtained equally favorable conditions of caries control by the use of diets which do not contain any such large amounts of citrous fruits or other vitamin C bearing foods.

MARTHA R. JONES

Martha R. Jones, a biochemist, has been studying a special form of dental disorder which appears very commonly among the children in the Hawaiian islands and to which the name "odontoclasia" has been given. She has recently issued a series of articles[36] in which she describes not only odontoclasia, but also dental caries, which is very prevalent among the children of these islands. In her work, she has attempted to analyze the various factors which may enter into the problem of dental caries with special reference to the influence of race and diet.

In her analysis of the situation, she lays great stress on the alkaline ash and the influence of the acid base balance of the diet, and states that when the diet of children 3 years of age or older contains fruits and vegetables in amounts suffi-

35. Eddy, W. H.: Improvement in the Quantitative Assay of Anti-Scurvy Vitamin C, Am. J. Pub. Health, 19: 1309-1320 (Dec.) 1929.

36. Jones, Martha R.: Larsen, N. P., and Pritchard, G. P.: Dental Disease in Hawaii (I), Dent. Cosmos, 72:439-450 (May) 1930; (II), ibid., 72:574-577 (June) 1930; (III), ibid., 72:685-699 (July) 1930; (IV), ibid., 72:797-810 (Aug.) 1930.

cient to produce an alkaline ash, there is little or no active caries of the teeth, regardless of how the diet is otherwise constituted. She found that active caries was always associated with diets that contained an excess of acid over basic elements, but that many persons on such diets, particularly Filipinos, had no dental decay. She states that candy and sweets *per se* do not appear to be an etiologic factor in the high incidence of dental caries in Hawaii. She furthermore states that sunshine, cod liver oil, eggs, orange juice, tomatoes and milk, both human and fresh pasteurized cow's milk, in good measure, do not prevent the rampant disintegration of the teeth (odontoclasia) of infants and children during periods of accelerated bone growth.

She believes that the activity of dental caries is not a fixed quality, but is rather a fluctuating one, the result of many factors, such as age, state of health, climate, environment, activity and diet, but she states that these combinations influence the liability of the teeth to caries through a decrease either absolute or relative in the amount of base in the tissues fluids and oral secretions.

In an attempt to explain the mechanism by which the acid base balance of the body fluids influences dental caries, she refers[37] to Bödecker's theory,[38] which states that the enamal is porous, and may be permeated by fluids from the interior of the tooth, and furthermore that odontoblasts are specialized cells whose main function is nutrition of the dentin and enamel and that through these cells "dental lymph" is delivered through dental tubules to the dental enamel junction and thence through the enamel to the surface of the tooth. Bödecker believes that when the blood plasma is normal, the "dental lymph" which is derived from it is alkaline in reaction and tends to neutralize the lactic acid formed by the bacteria on the tooth surface. When the alkaline elements of the blood plasma are low, the "dental lymph" does not possess adequate neutralizing power to combat the acids of fermentation, and dental caries results.

Dr. Jones concurs in this hypothesis in general, disagreeing only in the explanation as to the part which the odontoblasts play in the process. She also stresses the importance of the part played by the saliva as a neutralizing agent and makes the following statement regarding her point of view of the controlling factor in dental caries:

> We regard the "exciting" cause of dental decay as the *balance* between the saliva and lymph, on the one hand (both being derived from the blood plasma and comparable in reaction) and acid formed by bacteria in the oral cavity, on the other. Protected regions of the tooth allow the accumulation of acid, though the saliva and lymph may be normal in composition, and hence localized decay—caries—which might have been prevented by greater cleanliness.

Comment.—Her previous work with the stomatologic group research in California has made Dr. Jones quite conversant with dental pathology and has enabled her to think clearly in terms of that subject. Her wide nutritional training has also fitted her for a study of diets of children in Hawaii, and to correlate them with dental conditions which she finds. Her writings, which show a painstaking attack on the problem and a clear insight into the general field of dental health, constitute a valuable addition to the researches which are being made upon the subject.

37. Footnote 36, fourth reference.

38. Bödecker, Charles F.: New Theory as to Cause of Dental Caries, Dent. Cosmos, 71:586-598 (June) 1929.

THE MICHIGAN GROUP

During the past five years, a research group in the dental school of the University of Michigan has been studying the problem of dental caries with special reference to the bacteriologic and nutritional factors which may be involved. In the contributions of this group, an effort has been made to determine what is known concerning the problem and to evaluate the findings in terms of established fact. They disagree with the concept that dental caries is determined by the hardness or softness of the tooth, on the grounds that poorly formed teeth often are wholly free from the disease, while apparently well-formed teeth may be seriously affected. They further state that, although dental caries can be influenced by the hygiene of the mouth, its occurrence is not necessarily dependent on mouth cleanliness. In their search for the most prominent variables between individuals immune and those susceptible to caries, they have found that the presence or absence of certain aciduric types of micro-organisms in the mouth constitute the most characteristic variable between these two groups which has thus far been determined.

The bacteriologic studies which they have made were based upon the preliminary work of McIntosh, James, and Lazarus-Barlow[39] and that of Rodriguez,[40] in which the importance of certain specific types of aciduric organisms to the process of dental caries had been emphasized.

In the bacteriologic and clinical survey of several thousands of persons of various ages, the following observations have been made[41]:

1. An acidogenic and aciduric type of micro-organism, apparently identical with *B. acidophilus,* was found to be present in practically every lesion of active dental caries.

2. This organism is not present in the mouths of some persons who are entirely free from dental caries. In such mouths, there appear to be conditions that are unfavorable and antagonistic to the growth of the organisms. When *B. acidophilus* cultures are implanted therein, they promptly disappear.

3. Previous to the inception of active caries in the teeth, active proliferation of *B. acidophilus* in the oral cavity can usually be demonstrated.

4. The elimination of *B. acidophilus* from the mouth, either spontaneously or through experimental procedures, is always followed by a complete cessation of dental caries.

5. By the experimental application of cultures of *B. acidophilus* to teeth in the

39. McIntosh, J.: James, W. W., and Lazarus-Barlow, P.: Etiology of Dental Caries, Brit. Dent. J., 43:728 (Aug. 1) 1922; Brit. J. Exper. Path., 5:175 (June) 1924.

40. Rodriguez, F E..: Studies in Specific Bacteriology of Dental Caries, Mil. Dent. J., 5:199-214, 1922; Incidence of Lacto-Bacillus Acidophilus, J. A. D. A., 17:1711 (Sept.) 1930.

41. Bunting, R. W., and Palmerlee, Faith: Rôle of B. Acidophilus in Dental Caries, J. A. D. A., 12:381 (April) 1925. Bunting, R. W.; Nickerson, Gail, and Hard, Dorothy G.: Further Studies of the Relation of B. Acidophilus to Dental Caries, Dent. Cosmos, 68:931 (Oct.) 1926. Bunting, R. W.; Nickerson, Gail; Hard, Dorothy G., and Crowley, Mary: Further Studies of the Relation of B. Acidophilus to Dental Caries: II, ibid, 70: 1 (Jan.) 1928. Bunting, R. W.; Crowley, Mary; Hard, Dorothy G., and Keller, Margaret: Further Studies of Relation of B. Acidophilus to Dental Caries: III, ibid., 70:1002 (Oct.) 1928. Bunting, R. W.: Certain Considerations in Problem of Dental Caries, Dent. Cosmos, 72:399-407 (April) 1930. Bunting, R. W.; Hadley, Faith P.; Jay, Philip, and Hard, Dorothy G.; Problem of Dental Caries, Am. J. Dis. Child., 40:536-548 (Sept.) 1930.

mouth, carious lesions have been produced.

In assuming that the bacterial factors of dental caries are highly important determinants of the disease, the Michigan group have attempted to control it through eradication of *B. acidophilus* from the mouth. To this end, three lines of attack have been considered:

1. The attempt to discover in the saliva of persons immune to caries an inhibitory principle that is antagonistic to the growth of *B. acidophilus,* and that, when introduced into the blood or the oral cavity of susceptible persons, would eliminate the organism.

2. The study of the relationship of diet and nutrition to the growth and activity of *B. acidophilus* in the mouth, to determine whether caries-forming organisms may be controlled by a regulation of the diet.

3. A study of the effectiveness of various prophylactic and therapeutic procedures in eliminating *B. acidophilus* from the mouth.

They report experimentation on animals and on the human being in which dietetic and therapeutic measures were employed. The attempt to control caries by therapeutic means was more or less disappointing, but definite results were obtained through dietetic measures. As a result of feeding a fairly well-balanced ration to three groups of children in orphanages, numbering 433 individuals in all, active dental caries was reduced to a negligible quantity over a period of one year.

The diet prescribed was the regular institutional diet fortified only by 1 quart of milk, and from one to two green vegetables or fruit salads daily, and a reduction of sugar in all forms to a minimum. No cod liver oil or viosterol was given except in the case of a few undernourished children. The reduction of sugar was based on the assumption that the average child consumes too much carbohydrate in the form of candy and highly sweetened foods, as a result of which the appetite for other foods is perverted and a state of nutritional unbalance is produced. Furthermore, candy and sticky confections retained about the teeth afford a most favorable pabulum for acid fermentations in the mouth.

Comment. — In its publications, this group has accentuated the importance of the bacteriologic factors involved in dental caries and the significance of *B. acidophilus* as the chief etiologic agency in the production of the disease. They do not hold that dental caries is wholly due to local agencies, but rather that it is dependent on many constitutional factors, such as heredity, age, bodily health and nutritional states.

Their point of view has been somewhat different from that of others who believe that dental caries is controlled through an increase in the resistance of the tooth by change in structure.

The data which they have obtained through a survey of thousands of cases over a period of several successive years have impressed them with the importance of localized bacterial activity in the mouth in contact with the teeth as the specific exciting factor in the determination of dental caries. The activity of these organisms and their specific action on the tooth is directly related to many constitutional and metabolic factors.

Although these bacteriologic studies have been corroborated by other workers in this field, the relative importance of *B. acidophilus* in respect to all other factors involved remains to be determined. It is very possible that no one all-important factor exists, but that dental caries is the result of various localized

conditions, such as bacterial activity and acid fermentation, the quality and resistance of the tooth, and the character of the saliva and environmental influences, as well as the underlying constitutional states on which they are all dependent.

SUMMARY

As we review, in this manner, the recent contributions to the subject of dental caries, we are impressed chiefly by the fact that an unusual amount of interest is being shown in the subject, and that real progress is being made toward the ultimate solution of the problem. It is also evident that, as the study progresses, certain definite schools of thought are springing up based on the various hypotheses which are held regarding the nature of the disease and the means of controlling it. These may be classified into three general groups as follows:

1. Those who consider that the most important factor in dental caries is the resistance of the tooth itself (Mellanby, Howe, Boyd and Drain, Hanke and others).

2. Those who consider that the neutralizing powers of the saliva are the most important (Hawkins).

3. Those who consider that the activity of the aciduric organisms in the mouth is the most important factor (McIntosh et al., Rodriguez and the Michigan Group).

Certain of the first group speak of the control of caries as being largely resident in the physical structure of the tooth, dependent on either perfection of its development or on changes which may take place in the enamel and dentin subsequent to the eruption of the tooth. In their opinion, the tooth may be so highly calcified that it is impervious to the acids of caries and is thereby impregnable to the disease. Others have a somewhat different view in this regard, namely, that the tooth may resist dental caries through the neutralization of the acids of caries by alkaline elements brought to the surface of the enamel from the dental pulp.

The second group believe that the tooth, especially the enamel, plays a passive rôle in the process of dental caries and that the environment of the tooth is the most important factor associated with the disease. They believe that the saliva, through its alkaline properties, may neutralize the acids of caries and by its calcium content may condense the surface of the enamel, and thus prevent the characteristic action of caries.

Both groups accentuate the importance of calcium metabolism and acid base balance as factors in dental caries and recommend the adoption of certain diets which tend to increase the calcium and alkaline properties of the blood and saliva as a means of controlling dental disease. Again, we find a difference of opinion in that some believe that calcium and vitamin D factors in the diet are most important, others that vitamin C and still others that acid-base balance are necessary considerations.

Martha R. Jones and F. W. Broderick[42] emphasize the importance of acid-base balance of the body fluids in their relationship to dental caries, and believe that they operate both through the pulp of the tooth and through the saliva. In this, they support those of the first and second groups, who consider the acid-base balance of the blood and saliva to be important factors in the problem.

The third group, like the second, believe that the environment of the tooth is more significant in relation to dental caries than is the structural quality of the tooth itself. Of these environmental fac-

42. Broderick, F. W.: Dental Medicine, St. Louis: C. V. Mosby Co., 1928.

tors, they emphasize the importance of certain forms of aciduric bacteria and state that these organisms have a specific etiologic relationship to the disease. In the attempt to control dental caries through the limitation of the aciduric types of oral bacteria, the only practical method which they, thus far, have determined has been that of feeding adequate, well-balanced diets.

Although in the various diets recommended by the several groups, vitamin D has been emphasized in some instances, in others vitamin C and in others increased alkaline ash, the fact remains that all of the diets recommended have been fairly adequate for the general nutritional needs of the individual. The success in controlling caries that has followed the use of these diets indicates that, as far as dietary control is concerned, an adequate and well-balanced diet is a most important essential, and that considerable latitude in the choice of food may prevail. In this connection, it is interesting to note that the Michigan group succeeded in controlling caries in three large groups of children by the use of a simple inexpensive diet within the food budget of the average family.

There is no experimental animal entirely suitable for use in intensive studies on the relation of diet to dental caries. This being true, it seems highly desirable that efforts be directed in the future toward more scientifically controlled dietary experiments with human subjects. Only in this way can we hope to learn whether it is excess sugar eating, excess cereal eating, deficiency in vitamins C or D or deficiency in alkaline ash, or a combination of dietary faults, that is responsible for the wide spread of caries among civilized peoples.

As we review all the experimental data which have been reported by the various workers in this field, we are impressed by the degree of success which has been attained in the control of dental caries by the feeding of many different types of diets all of which were adapted, more or less completely, to the needs of the individual. These constitute the most successful practical means of preventing the disease which so far have been offered. Prophylactic and operative measures, which, in the past, have been the sole means of controlling the caries, were but relatively successful. Until recently, no definite means of prevention were known. Today, we have a wealth of evidence which points toward the possibility of controlling this disease through diet, a method which when perfected may prove to be quite as definite as is the dietary control of diabetes and other metabolic disturbances. As in diabetes, the success of these dietary measures will depend on the constitutional status of the individual, the severity of the disease and the extent to which the nutrition can be balanced to the needs of the individual. It is probable that the conditions under which Boyd and Drain worked, in which the patients were hospitalized and the diets were balanced and weighed and constantly controlled, are most nearly ideal. That is, in cases of extreme caries susceptibility, it may prove to be advisable to put the patient under nutritional supervision similar to that of diabetic cases. Certainly, in this manner, the dietary measures would be most effective.

It is apparent that such strict measures of dietary control could not be applied to any large numbers of individuals, and since dental caries is a disease of the masses, any adequate solution of this problem must be founded on a much simpler and more widely adaptable program.

It is gratifying to note that more simple dietary procedures, which may be carried

out in public institutions and in the average private home, have proved to be highly successful in the control of caries in large groups of individuals. Such reports strongly indicate that prevention of dental disease through practical measures of dietary control is a reality.

Although the dietary studies appear to be so promising, it must be remembered that other factors of major importance enter into the problem. Heredity, age, bodily health and constitutional characteristics all play important parts in the general scheme of dental health. In the search for the all-important controlling influence, these other factors must not be left out of consideration.

Studies of this subject are but in their infancy, and no one believes that the problem is solved. All factors concerned must be considered, and comprehensive investigations must be made by scientifically trained observers in each of the allied fields of science before any definite concept of the disease and the means of its prevention can be established.

LABORATORY STUDIES IN MOUTH PATHOLOGY*

By WILLIAM G. DOWNS, Jr., D.D.S., Ph.D., New Haven, Conn.

I AM interested in many subjects which concern the study of mouth pathology and enjoy discussing them in any of their phases at any time. When I begin to summarize what I have in exact knowledge of this broad field, I am appalled at the lack of such knowledge. I could raise many subjects for discussion or debate, some of which would, I hope, at least challenge interest. I can give you a considerable body of scattered data on various phases of my subject, but when it comes to offering you exact and detailed facts which may be applicable to your field of endeavor, I feel helpless.

I believe that this is true to a great extent of those who work in all fields of scientific endeavor. A great deal of research is of an apparently purely academic nature and interest. In the nature of scientific study, this is probably necessary. Few investigators are sufficiently fortunate to give to the world an outstanding and practical piece of research. Often, the experimentation which is acclaimed from all sides because of its practical importance and value or because it fulfils a long felt need is simply the bringing together by one man of the results of painstaking academic studies on the part of hundreds of other men, who have gone unacclaimed because, at that time, their work seemed to have no practical significance.

Any slightest advance in our knowledge of scientific and, particularly for our purpose, biologic studies; wherever the barriers of human knowledge are pushed farther out into unknown territories, any bit of space gained will, at some future time, be of value in a practical and worth while sense. I can only hope, therefore, that the few scattered facts which represent my own research results may, at least at some future time,

*Read before the American Society of Oral Surgeons and Exodontists, Evergreen, Colo., July 18, 1930.

be of value to another, who, building on such information, may give to the world some conclusive and practical bit of work.

It was my pleasure to show before the International Association for Dental Research a film, which some of you saw, showing the necropsy procedure in use in our laboratories. For the benefit of those who did not see this film, I shall sketch briefly what this procedure is. It is one which is used for many of the cases coming to necropsy in our department. We hope, in the near future, to be able to make it routine for all complete necropsies.

Fig. 1. — Lower right first molar from clinical case of myositis of right shoulder.

1. A culture is taken from the mucous membranes and flora of the mouth and is grown out in different mediums and under aerobic and anaerobic conditions, and direct smears are made of the case.

2. A full mouth roentgenogram is made, from which areas are selected showing some evidence roentgenographically of pathologic change. These and roentgenographically negative blocks are then cut out of the maxillae, a sufficient amount of surrounding tissue being taken so that no danger of contamination is experienced.

3. Access is given to the regions selected in such a manner as to do away with the possibility of contamination, and cultures are obtained from these areas and handled in the same manner as those obtained from the mucous membranes.

4. These blocks are further trimmed to convenient size for handling, and are decalcified, sectioned and studied for histopathologic changes.

5. Cultures are made of the more distant organs and viscera, and in particular of lesions which are found grossly, and are grown out in the same manner as

Fig. 2.—Upper right first molar from necropsied case.

those previously mentioned. After all of the data obtained from these various procedures are available, each case is then gone over in great detail and studied from the point of view of the possibility of systemic infections arising from mouth organisms or from mouth infections, also the possibility of mouth infections arising from those found primarily elsewhere.

An attempt is made to study the histopathologic changes resulting from mouth infections and periapical and periodontal foci. In other words, some effort is being

made in this direction to obtain information as to the natural history of mouth disease and its relationship to that of the human body in general. We feel convinced that disease in the mouth is just as much disease of the body as is that of the kidney.

Further than this, these studies are amplified by implanting cultures of the organisms obtained from these necropsies at the apices of the teeth of experimental animals. In this phase of the work, the general procedure of Moon,[1] in which

Fig. 3.—Mandible of experimental dog in which Streptococcus viridans from the case shown in Figure 2 was placed on cotton at the apex of the lower right cuspid of the dog. This roentgenogram was made directly after operation.

cotton pledgets soaked in heavy emulsions of the organisms are implanted through the root canal in the periapical region, is followed and, usually, an amalgam filling is placed in the tooth. Roentgenograms are made of these teeth at regular and

1. Moon, V. H.: J. Dent. Res., 10:399 (Aug.) 1930.

frequent intervals to obtain information as to the roentgenographic changes to be expected from particular types of organisms at different periods in their growth. These roentgenograms are constantly checked against those obtained from the human subject from which the cultures were originally obtained. At different periods during this series of studies, animals are killed and put through the same routine as are the human bodies from

Fig. 4.—Case shown in Figure 3 about two weeks later, when only a slight, if any, change may be seen.

necropsy cases, cultures being obtained from the apices of the teeth, cultures from all of the other organs and histopathologic preparations from the teeth and surrounding tissues. These are checked against each other and against the findings from the human case furnishing the cultures originally. These studies have been in progress for over a year, and

while, as I have said before, I cannot bring to you any definite, conclusive data from them, a few indications have come to light.

I have selected a few illustrations from cases which I believe are an indication of two or three points which I desire to make. I present you, first, one of our earlier cases, in which the animal experimentation was not utilized as a check. It is otherwise so interesting that I felt it worthy of presentation. The most remarkable points in this patient's history are that, somewhat over a year before admission to the hospital, he had an abscessed tooth, which was shortly removed. Thereafter, he had an attack of antrum infection which continued in its acute stages for a month, but which apparently cleared up. Several weeks later he noticed a discharge from both ears, which had intermittently continued until the time of admission to the hospital. The immediate cause for admission was uremia, with apparent infective nephritis. On necropsy, this clinical diagnosis was confirmed, the cultures obtained from both antra, the middle ear, the kidney, and the bladder in each case showing a hemolytic type of *Staphylococcus aureus*. While one may not say positively that such was the case, it seems quite probable that this patient's original infection was from the abscessed tooth, whence it was transmitted to the antrum, then to the middle ear, the kidney infection, which was the immediate apparent cause of death, eventuating. We do not often see cases in which the sequence is quite so clear cut, but they do occur sufficiently

Fig. 5.—Upper incisor region of a necropsy case, showing definite changes at the apices of the two devitalized teeth, from which region cultures of Streptococcus viridans were obtained.

Fig. 6.—Mandible of experimental dog in which organisms from the case shown in Figure 5 were placed at the apex of the lower right cuspid of the dog (taken just after operation).

frequently to make our efforts seem worth while.

The second case which I wish to present is a clinical one. In this case, the patient had been suffering from acute distress in the right shoulder, either myositis or arthritis, for a considerable period before he was seen by us. He had had a complete physical examination with only negative findings. Roentgenograms were made and were interpreted by the roentgenologist as negative. (Fig. 1.) In spite of our respect for the opinion of the roentgenologist, we felt that the upper right second molar and the lower right first molar were sufficiently suspicious to warrant removal. In view of the opinion of the roentgenologist, the patient objected to this procedure, and at first refused to have the teeth extracted. An acute exacerbation of his condition drove him back for relief, and he finally very reluctantly consented to the extraction.

Fig. 7.—Case shown in Figure 6, about six weeks later.

The two teeth were extracted under general anesthesia by Dr. Fahy, of New Haven, and with all of the precautions possible in such conditions, were cultured in the various mediums already mentioned. In each case, an almost pure culture of *Streptococcus viridans* was obtained, which convinced us that this had been the predominating organism. Remarkable as it may seem, the patient admitted that the night after the removal of these teeth, which was only a few hours afterwards, was the first time in many weeks that he had been able to sleep on that shoulder. A few days later, he had a return of his acute shoulder symptom, which we felt might be due to a loss of drainage from the healing over of the sockets. For this reason, they were opened, and immediately he felt relief in the shoulder region. From this time on,

Fig. 8.—Case shown in Figures 6 and 7, about three months later.

his symptoms were gradually relieved until they are at present completely gone, and he has returned to his former very healthy condition.

I quite well realize that any of you could duplicate this clinical story many times over, but it fits well into the picture that we are very frequently seeing and assists in making a point which I hope later to bring up.

The next two cases are from necropsies which were followed up by the experimental work on dogs. In the first of these cases, a nephritis, a culture was obtained from the upper right first molar, from both antrums, and from the right kidney, all of which showed the presence of *Streptococcus viridans,* and, in the left antrum, other organisms normally found among the mouth flora were revealed. (Fig. 2.)

On the surface, this seems to be a quite clear-cut picture of systemic disease following focal infection. From the clinical data in the case, there was a good deal of evidence to lead one to believe that the infection was secondary to an attack of scarlet fever. In spite of this, the usual routine was followed, and cultures from the apex of the upper right first molar were implanted at the apex of one of the cuspids of an experimental dog. A roentgenogram of this animal taken immediately after operation shows no periapical changes. (Fig. 3.) Figure 4, taken about two weeks later, shows the condition practically unaltered.

At this time, the animal was killed and necropsy performed, and the cuspid operated on as well as the more distant organs cultured as I have described. Strangely, the periapical region of this tooth was apparently sterile, and the only organisms obtained from a more distant organ were of a type not at all similar to *Streptococcus viridans* in any of its known stages.

Of course, we must realize that the dog is an animal having a considerably advanced immunity to cocci. Even with this in mind, such studies as the one just outlined and that of Valentine[2] and her associates make one pause to consider before he too quickly accepts the entire theory of selective localization of bacteria.

The next case gives a somewhat different picture and still further raises a question as to how such things are to be interpreted. In this case, which was one of predominantly meningococcus infection, there was found *Streptococcus viridans* in large numbers at the apex of the upper right lateral incisor (Fig. 5), and, growing with it, a few other organisms.

The same routine was followed as outlined before and the roentgenograms were made of the experimental animals at similar intervals. Figure 6 was taken just after operation. Figure 7, taken after about six weeks, shows a slight change. Figure 8, taken within the past few days (at about three months), shows an obvious change. This animal has not as yet been killed and examined as we wish to observe the later changes around the apices of his teeth. You will notice that the apex of the tooth cultured shows a material change, while the corresponding tooth of the opposite side shows a rather definite periapical and periodontal involvement. Whether this lends support to the theory of traumatic occlusion as being etiologic to such conditions, we cannot say. Neither, until the cultural results are obtainable, may we say what the infectious agent may be. But again such pictures cause the observer a great deal of doubt.

I might have presented many cases to demonstrate almost any theory which I

2. Valentine, E., and Von Meter, M.: J. Infec. Dis., 47:56 (July) 1930.

chose to support. I have chosen to present cases which, in large part, are productive of questionable results. I am doing this with the express purpose of demonstrating how easily one may be misled in attempting to interpret data obtained even under the most careful laboratory conditions. I wish to say further about this phase of the work (and did I choose to present large numbers of findings, I could beyond question convince you of the reason underlying my statement) that, in the aggregate, our studies to this point have indicated the following:

1. In general, the periapical lesions not having a distinct outline and clear-cut form in the roentgenogram are those most apt to be pure cultures of organisms and, in particular, *Streptococcus viridans.*

2. The roentgenographically very clear-cut and outstanding periapical infections are more apt to be productive of mixed cultures.

3. It is, in general, the former type which are more apt to respond quickly and definitely to removal of the infected tissues where more distant symptoms are found accompanying the mouth involvement.

4. Practically all, if not quite all, of the bacteria coming from mouth foci grow better under anaerobic conditions.

5. The roentgen ray may not be relied on entirely as a basis for diagnosis, and the microscope does not have the general usage which it deserves as a further aid in diagnosis.

6. All experimental data of this nature must be carefully scrutinized and many factors taken into consideration. There is a tremendous species difference in the response to infections of all sorts. Individual variation within species is likewise very great. Our methods of grouping bacteria, and, in particular, streptococci, are at present not entirely satisfactory.

Henry A. Miller,[3] working in our group, has been for the past year making a study of the reactivity of streptococci, attempting to devise methods of grouping these organisms. Morphologic groupings alone are somewhat unsatisfactory in the light of recent studies in serology and immunology. The fermentation reactions are possibly an improvement, but are still not sufficiently definite. (Miller, 1930.)

OCCURRENCE OF ORGANISMS IN PERIAPICAL INFECTION[3]

S.viridans pure	14 cases
S.fecalis pure	2 cases
S.viridans and staph. aureus	1 case
S.viridans, staph.aureus, diptheroid	1 case
S.viridans and B.coli (atypical)	1 case

Up to the present time, the agglutination tests have not been too promising, so that when we find *Streptococcus viridans* at the apex of the tooth and *Streptococcus viridans* in the kidney, it is by no means an assured fact that they are identical organisms. Hence, it is certainly not assured that the route of infection has been from one observed locus to another. Our methods of grouping these organisms must be greatly improved before such an assumption can be safely made.

Again summarizing the indications from the necropsy and bacteriologic studies outlined: In general, the cases which show roentgenographically small and poorly circumscribed periapical areas are the ones from which pure cultures of pathogenic organisms are frequently obtained. The larger, well-circumscribed areas roentgenographically usually show mixed cultures and, on the whole, cultures of organisms probably having a very low virulence. Generalizing again, one

3. Miller, H. A.: J. Dent. Res., 10:381 (Aug.) 1930.

may safely say that the organisms obtained from periapical lesions are not those having a high virulence.

We are inclined to believe that the danger lies probably in the liberation of low-virulence bacterial emboli or of toxins over long periods of time, with their cumulative effects on already weakened or overworked organs or tissues. This is, of course, to a very great extent in line with the opinion which many others have expressed earlier, but we believe that our approach will add something to the detailed knowledge of the natural history of these disease processes.

It is apparent that the first reaction to infection in the periapical region, as elsewhere, is the invasion of polymorphonuclear cells and plasma cells. As the condition becomes chronic, these are gradually replaced by mononuclear cells, connective tissue reaction begins and, finally, the entire lesion, under normal conditions, may be walled off from the surrounding tissues by a rather thick and dense layer of connective tissue. Thus, it seems obvious that the lesions that one should be most interested in removing are the earlier ones, when no protecting mechanism has been thrown up in the region involved, and perhaps the individual has not had an opportunity to build up an immunity to the toxins liberated; in short, the ones which are most often temporized with.

Again I would suggest that it may be very worth while to follow the developments in the studies of methods of identifying organisms by serologic typing.

The excellent studies of Rickert[4] and his group, as well as others in similar directions, seem to indicate that, in the hands of a very careful operator, it is possible to satisfactorily treat root canals and not cause the infection of the surrounding tissues. The cases which we have seen at necropsy lead us to believe that all teeth having filled root canals should be viewed with the gravest suspicion, and, from our observation to date, I am sure that none of our subjects during their life time had the advantage of such a careful root canal technic. In a considerable number of such teeth which we have had an opportunity to study, we have so far found none which fail to yield a definite culture of one or more strains of bacteria. On the other hand, of an equally great number of control teeth which were roentgenographically normal, only one has shown the presence of infection and that was from a case of definite bacteremia. These experiences lead me to believe that if root-canal therapy is to be utilized in dentistry, only a very high type of technic may be employed, and that only the most skilful of practitioners should attempt it.

I should feel that I were failing in my duty to you, and to my group should I fail to mention the possibilities which lie in the study of metabolic deficiencies. We are very fortunate in having available a large amount of experimental material coming from laboratories where metabolic studies are being made. Lafayette B. Mendel and his co-workers have kindly placed at our disposal the heads of all of their animals on various types of abnormal feedings. The various stages of rickets, scurvy, vitamin-A deficiency, vitamin-B deficiency, overdosage of each of these vitamins, low and high ash diets, low and high protein diets, and low and high fat diets, as well as diets showing various disturbances in the calcium-phosphorus ratio, are represented. In addition to these, we are studying the

4. Rickert, U. G.: J.A.D.A., Status of Pulpless Tooth from General Practitioner's Point of View, 17:1020 (June) 1930.

various endocrine effects on the dental mechanism. It will be a considerable time before all of the data from these series of studies are available. J. J. Wolfe[5] and others are working up this material for histopathologic study, and from it, we hope to have considerable, valuable information as to the rôle played by these metabolic variations in the production of dental and oral disease. In many of these instances, the changes are certainly very slight and their recognition in histopathologic preparations will require a great deal of careful comparison and analysis. Drawing on the indications of some of our own work, as well as that of such investigators as Howe[6] and Wolbach,[7] we are able to build up certain hypotheses upon which to work. The mouth is very probably an excellent index as to the metabolic state of the individual. The symptoms of scurvy in the oral cavity have been known for a long time. In fact, for many years, it was only through these symptoms that this disease was diagnosed. More recently, studies on rickets have divulged the importance of the developmental state of the teeth as a diagnostic sign in rickets.

We have had an opportunity to study a limited number of preparations of the teeth and jaws of animals on a diet deficient in mineral salts for periods up to sixty-three days. There had been softening of the bones and thinning of the cortical plates similar to the changes found in osteomalacia. Microscopically, there is osteoporosis, many large multinucleated cells are present and the bone-islands are undergoing dissolution. The dentinal tubules are dilated and the dentin vacuolated. The enamel shows an apparent relative increase in the organic matrix, and disintegration of the enamel rods. The pulp is a maturer connective tissue than normal, and the blood-vessels are dilated and the odontoblasts pulled away from the dentinal wall. There are points of similarity in both the gross and microscopic pictures between this and many other deficiency diseases. (Wolfe, 1930.)

In the series of endocrine studies, only those dealing with pituitary dyscrasias have so far been studied to any considerable extent. In these studies, the growth extract of the anterior lobe was fed to tadpoles and injected into mice and dogs. Dogs also were the subject of operations, in which the entire hypophysis was removed. The whole tissues of the mice were chemically analyzed and checked against those of their control litter mates. From these studies, it was determined that the growth hormone of the anterior pituitary caused a marked acceleration in growth, an increase in water retention in the tissues, increased calcium retention and decreased fat formation. It influenced the development of the teeth and jaws in the direction of accelerating the growth of the teeth and, to a lesser degree, increasing the size of the maxillae. It did not cause malformation of teeth or jaws or absence of any of the teeth. (Downs, 1930.)[8]

It becomes apparent from these groups of studies that metabolic and nutritional states definitely influence the teeth and their adnexa, and that we must look to such etiology in many of the conditions found in the mouth. It is not impossible, certainly, that as we learn more about

5. Wolfe, J. J.: J. Dent. Res., 10:388 (Aug.) 1930.

6. Howe, P. R.: Dent. Cosmos, 62:586 (May) 1920.

7. Wolbach, S. B., and Howe, P. R.: Arch. Path. & Lab. Med., 1:1 (Jan.) 1926.

8. Downs, W. G., Jr.: J. Dent. Res., 10:396, 393 (Aug.); (Oct.) 1930.

the metabolic deficiencies, other diseases of this type may be similarly diagnosed in the mouth.

Our present view of the subject is that, usually, nutritional deficiencies are not simply the product of a lack of a single vitamin or food element, and are considerably more complex in their nature. With this in mind, I should hesitate to narrow down too closely the diagnosis of nutritional deficiency. Frequently, with the most careful study, one is unable to make such a diagnosis. In this connection, the following case was recently presented to my attention.

The patient was sent me by Dr. Kantor, of New Haven, with the following history: Two years previously, a stubborn, indurated ulcer had appeared on the left side of the tongue just after delivery of her first child. Different types of treatment had been utilized with no success. She was sent to a general surgeon, who, feeling that the stubborn nature of the condition warranted it, had made a partial resection of the tongue, with a tentive diagnosis of malignancy. At the time that I saw this patient, a similar ulcer had appeared almost on the site of the earlier incision, which likewise had failed to respond to local treatment. This and a rectal abscess appeared after the birth of her second child. She was prepared for another operation and possibly one on the rectum as well.

On further questioning, some additional facts were brought out in the history: first, that she had had, since childhood, very numerous "mouth sores," probably having some connection with the menstrual period; that while she was apparently well developed and well nourished, her diet was somewhat irregular and erratic in nature. A negative Kahn test was obtained, which ruled out the probability of syphilis, and a tuberculin test was negative.

It was possible to have access to the sections from the biopsy of the previous operation. These showed no evidence of malignancy. After careful study of the case, it was felt that there was the greatest likelihood, in spite of the well-nourished condition, of some nutritional or metabolic disturbance. The patient was hospitalized for observation and placed on a careful diet. No definite deficiencies were found by study of the case in the hospital, but after five days of hospital routine, she was discharged with the rectal abscess completely healed and the lingual ulcer having almost disappeared. This, again, is a type of case which brings to mind many questions. I cannot but feel that hers was a nutritional deficiency and that the carefully supervised hospital diet and regimen corrected this lack. Might not similar cases respond to the same type of treatment?

CONCLUSION

I should like to emphasize the great caution which one must exercise in interpreting all investigative data, which are, after all, statistics and are susceptible of a great deal of juggling, as are all statistics. It is extremely difficult not to interpret them in the light of subjective reasoning. It is not always easy to be strictly objective in analysis, but the pursuit of science can be served in no other way. Dental and medical studies are, after all, phases of the biologic branches of science and must be judged in the light of a broad understanding of biologic processes. The more one sees of these processes, the more cautious he becomes in his assumptions from them. I feel that we are gradually gathering a body of data as to the natural history of mouth disease and of disease in general that will

eventually be of a great deal of value. Perhaps some little of what I have given you may be capable of translation into practical terms. If I have impressed on you the need for extreme caution in analysis and interpretation, neither your or my time has been wasted.

DISCUSSION

Boyd S. Gardner, Rochester, Minn.: The part of Dr. Downs' paper on elective localization is most interesting to me, owing to the fact that our research, from a dental standpoint, has been largely from the bacteriology angle. I think more can be accomplished by dealing directly with the living subject than with findings at necropsy, as it has been definitely proved that, if much time elapses after a tooth is extracted, the streptococci will lose their powers of elective localization. I agree that further study of streptococci and their relationship to dental infection is important, and we should not overlook the fact that it is necessary to produce in the laboratory as nearly as possible the condition found at the apices of infected teeth. It is important not to lose much time in getting the specimen into the test tube, which should contain sufficient culture medium to allow the organism to grow at different oxygen tensions. It has been our experience that we obtain the same type of streptococci in other parts of the body as at the root ends of teeth. Particularly is this true of organisms recovered from an infected prostate. Animal inoculations further prove this point. Perhaps it would be of more interest to call attention to the work of Jensen, who has attacked the problem of elective localization from a different standpoint. He contends that all organisms carry a definite electrical charge and, by a special apparatus, he determines the rapidity with which the organism will travel from the negative to the positive pole and thereby measures their electric charge. He finds that organisms that will elect different tissues of the body will travel over the field with different rates of speed, and, by determining their charge, he is able to predetermine what tissues they will elect when injected into an experimental animal. Thus, it is possible, by this agreement, even to suggest, at least to some degree, what organ of the patient was affected. Research from a bacteriologic standpoint is of course interesting to us all, but, to most of us, it is by finding out what we are accomplishing for our patients each year, and obtaining more definite results by knowing more about the systemic condition of our patients, that we can determine just what rôle dental infection is playing in the practice of medicine. The work on dogs is extremely interesting to me because we have done so much of it at the Mayo Clinic. Everyone who is doing any animal work is interested in the different methods of obtaining the dental specimen. I would therefore like to have Dr. Downs tell us just what his procedure is in obtaining the specimen from the root end of the tooth. Dr. Rounds has stressed the importance of carrying on work from a research standpoint, and I am sure much can be obtained by systematic effort. I think that a group which is spending money obtained from the American Dental Association should get together frequently, and attempt to standardize ideas so that there may not be so much repetition, and therefore so much loss of time, as well as money.

W. J. McLaughlin, Bridgeport, Conn.: This point of infection, from Dr. Downs' paper and parts of Dr. Gardner's talks, presupposes an invasion of bacteria from without. About a year ago, at a meeting of our local organization, a Dr. Bassler, from New York, told us that we were wrong—that the invasion of bacteria is not from without. We have been taught that bacterial invasion is from the outside in, and this discussion presupposes that Dr. Rosenow's experiment with a dog would indicate strongly invasion from without. Dr. Bassler tells us that we are wrong. He may be right. He says: "I have proven in my laboratory that the invasion by bacteria of these areas that you dentists believe is from without, in reality comes from the blood stream." It is my opinion that he is partially right, as judged by our every day practice. A child receives a blow in the tooth, say a central incisor. Devitalization of the pulp results. Circulation is shut off and, in a year, there may be an acute flare up. It is logical to consider that there has been a hematogenous invasion because there has been no external break. It is for this reason that I am interested in what Dr. Rosenow is doing. I should like to have Dr. Downs state whether he thinks there is any logic in this reasoning. Dr. Bassler I am sure has no preconceived opinions, and when a medical man speaks with authority and tells the dental and med-

ical world that we are working backwards, it is something to think seriously about.

M. F. Wielage, Miami, Fla.: We are becoming confused because the one says that the bacteria come from within and the other says from without. Is it not true that we have really come to the stage where we are getting away from bacteria? I can readily see that somebody can receive a blow on a tooth and Nature will fight the resulting poison or toxin just as much as it will fight toxin of bacteria. Consequently, it has not been proved that the bacteria come from within. There is one particular thing that I should like to ask: Dr. Downs mentioned the case of a patient who had an ulcer, was taken to the hospital and, without treatment, got better. I do not know what kind of treatment that patient received, but I can treat a patient without medication. I can change the surroundings, afford rest and quiet, and improvement will result. Metabolic changes are brought about by changing the surroundings. Perhaps there was some condition in the patient's surroundings which prevented the ulcer from healing. Perhaps by taking the patient over to the hospital, where pleasant care was received from the nurses who attended her, a metabolic change might take place and the case heal without medication. I do not think we are ever going to be successful in trying to find the cause of our troubles by looking only at the material, physical side of man. In taking a necropsy case, I doubt that we could tell a second after the individual is dead what the difference is between the living and the dead. If you will make an analysis at that time, you will find that they are alike and still something is missing. There has been some change. As Dr. Gardner has said, it is better to work from live material because, after all, that is what we are interested in. We are not interested in the dead body.

H. M. McFarland, Kansas City, Mo.: I have in mind one question: What are we going to do about it? The fact of it is that you tire as I do of coming to meetings year after year and then going back home and seeing dentists who are practicing the same today as they did twenty-five years ago. We have men in our organization who pass these things by as if they had no importance. So the question naturally arises: What are we going to do about it? I think that this organization has possibly a greater responsibility resting upon its shoulders than has any other specialty of medicine for not cleaning up these cases. We have to deal with people who are sick. We were told by Dr. Downs that the death rate from heart disease is greatly on the increase, possibly owing in a large measure to focal infection. So I should like to emphasize that we should get together in some way or another and that we should use the information that we already have secured. I would, for one, like to ask Dr. Downs his opinion as to how we can get together to best use the knowledge that we have already secured from such men as Dr. Gardner has mentioned.

Frank S. Kaiser, Los Angeles, Calif.: I may be mistaken in this, but I thought that Dr. Downs said that, in putting this infectious material in the dog's tooth, there was no rarefaction at the end of that tooth, but that there was rarefaction on the other side that had not been treated. I do not see how it could become rarefied on the opposite side.

O. T. Dean, Seattle Washington.: It seems that this discussion has been entirely on devitalized teeth. I should like to ask Dr. Downs about the attention that they have given to the third molar. I find the greater percentage of those infected. He did not pay very much attention to that in his paper.

Dr. Downs: I am very sorry that I cannot answer the last question that was asked. In this particular case, it took all the salesmanship I possessed to get this man to have these two teeth out. He happened to be a professor in the Yale Medical School, which made it somewhat complicated. Referring to the particular case in question, the animal was still alive. I do not know what it means, but if you will accept my statement as just a guess, I will say that I think it is possible that there was a loss of function on the side of operation which threw an undue stress on the opposing cuspid, and that the changes may be entirely mechanical; they may not be bacteriologic changes at all. The dog is still living and will be for quite a long time. I can only say this, that, for my own part, I feel fortunate in having some extremely nice contacts through the International Association for Dental Research, where those of us who represent all these laboratories can get together in round table discussions and whip out many of these things. I want to come to this later when I answer Dr. Gardner, but it is appropriate right now. I may say that our present

technic is due in part to the fact that Dr. Cook spent several days going over with me some of the details of what we are doing. So I am not quite unfamiliar with that group's work. I do not know of a better way for men to check up on each other than in such groups as this. I do not think it would pay to too highly standardize the methods that are in use in the different laboratories and different groups. There is an individual approach to a subject that we should make use of rather than do away with, from the purely research standpoint, that is, as far as I can see it at present. We are attempting to do at Yale something that we hope will some day have an influence in that direction. It is an experiment in teaching; it is an experiment in dentistry. As probably most of you know, we are bringing in four men each year who are graduates in dentistry. They come on a stipend granted by the Rockefeller Foundation, and they spend four years in our laboratories. They have all had either some research training or some clinical training. In those four years, they are expected to spend half of their time in learning research, and we hope, as those men go out that they will carry on and thus help to form a body of dental research men. In addition to that, they spend half of their time in curricular pursuits, which at present will lead to a medical degree. Frankly, I am somewhat inclined to question the wisdom of that approach, but, as I say, it is all experimental, and I cannot say yet that it is not good. I think there are other such focal centers that will come into being in definite parts of the country. The one at Rochester has been the focal center of that sort of thing for a great number of years, and the men who are coming out of there are having a great influence on this type of thing. The mechanism of putting it over is one that it will take a great deal of time to work out. Before we can accomplish this, dental teaching must build up a basic philosophy. I mean that it must have a philosophic approach to its teaching problems, something which I am not quite sure that it has had. There is a philosophy of medical teaching and there is one of graduate teaching, but dentistry has largely been taught purely as an aggregation of subjects that somebody thought sometime, in some way, might be related. I believe that as such a philosophy springs up as fundamental to a teaching, whether that be as a branch of medicine or as a separate profession, these questions will almost solve themselves. What we have to do is to start interesting men in going about these things, and then perhaps out of such experiments will come some wise solution to the problem. I am sorry I cannot answer Dr. McLaughlin's question. I see no reason why bacteria should not be brought by way of the blood stream, into any weakened organ, whether it be a tooth, the kidneys or the prostate. Dr. Gardner brought out in my own mind some weak points in my explanation of the matter. Of course, anybody who pretends to do research of this character has to be familiar with the work that has been done by the Rochester group. If he hopes to accomplish anything by it, he has to be intimate with that work, and as I said a while ago, I feel that I have some contact with the immediate conditions there. Dr. Cook has not been away from there very long, and he was probably in quite close contact with what was done there until he left. I have been familiar with Dr. Rosenow's publications and that of the group, and naturally that has been somewhat basic to the work we have been doing at present. Primarily, our approach to the matter now more than anything else is to see if we can set up some standard of grouping bacteria rather than to see if we can standardize the occurrence of these things. Do not misunderstand me. I think frequently men who are not actively working in the field are inclined to go way ahead of the possibility of it in accepting a general theory of that sort, and it was to that that I referred when I said that I should not accept it too soon nor entirely. About the methods: We have not standardized the mediums that we have used. We have used everything from bouillons to sugar and meat mediums. The technic of obtaining the culture, whether by clinic or necropsy, is practically the same. We are doing these things just as much clinically, if not more so, than by necropsy, only we hope that out of the necropsy, we can set up hypotheses which we can try out in the clinic. In necropsy, these blocks are cut out as soon as the bodies are brought in. This block has been taken out so it includes quite a bit of hard material around the tooth itself. The bone is obtained from entirely around it. The entire surface has been sterilized.

Dr. Gardner: Do you sterilize the oral cavity at the time of necropsy?

Dr. Downs: No.

Dr. Gardner: Then how can you cut in?

Dr. Downs: By cutting a sufficiency out. The entire surface of this is sterilized. Usually, we cover the entire thing with iodin and then burn it off with a gas flame over the entire surface. We have controlled that sufficiently that we know there is no contamination in most of our cases, at least. For a long time, we have made surface cultures from all of those things and tested them against whatever strains we obtained from the periodontal region. Then, with a gloved hand and a sterile needle, we go into the region shown by the roentgen rays. It is done immediately after necropsy.

Dr. Gardner: How do your necropsy findings differ from those in the living? Do the organisms behave in the same way?

Dr. Downs (closing): We find little difference. One of the men in our laboratory, Dr. Burns, recently published an analysis of a postmortem invasion of bacteria. He has done some excellent work in that direction, and that, plus some of our own experiments, indicates that if we allow the body to go longer than eight hours, we cannot trust our findings too implicitly. As to the bacteriologic behavior, we do not know. That is what we hope to find out. Experimentation is affording us a great deal of material in grouping these things, and, so far, they appear to behave just as our strains do clinically.

AGE-INCIDENCE OF LINES OF RETZIUS IN THE ENAMEL OF HUMAN PERMANENT TEETH*

By JOHN H. SWANSON, Cleveland, Ohio

IT has long been recognized that the lines of Retzius, or incremental lines, indicate successive layers in the deposition of enamel. They range in a graded series from scarcely perceptible striations to relatively grave lesions, and reflect, by their magnitude and number, the changes that took place in the salt balance of the body as enamelization proceeded. The age at which each striation was created may be determined within narrow limits by reference to Pierce's[1] table of calcification or to the enamelization chart of Karnosh.[2] Thus, we are provided with a reliable record of every significant dystrophy that took place throughout the years in which the crowns of the teeth were forming.

In the work described here, the character and distribution of incremental lines of the enamel were studied in a collection of human teeth. The object was to discover whether the tendency toward the formation of hypoplastic enamel, as expressed by the presence of larger or more numerous lines of Retzius, is correlated with any particular age-period or periods.

Whether or not such correlation exists, knowledge of this subject should be of value to pediatricians and others dealing with children during the tooth-formative period, in that it would indicate over how long a period measures designed to insure better calcification of the teeth should be employed.

I am indebted to S. W. Chase, of the laboratory of histology and embryology

*From the Laboratory of Histology and Embryology, Western Reserve University.

*Work done with the aid of a grant from the Scientific Foundation and Research Commission of the American Dental Association.

1. Pierce, C. N.: Calcification and Decalcification of Teeth, Dent. Cosmos, 26:449-455 (Aug.) 1884.

2. Karnosh, L. J.: Histopathology of Syphilitic Hypoplasia of Teeth, Arch. Derm. & Syph., 13:25-42 (Jan.) 1926.

of Western Reserve University, for suggesting a study of this problem and for his sundry contributions to its solution. F. C. Waite, of this laboratory, has contributed much aid and timely advice as the work progressed. T. J. Hill and H. R. Van Natta of the department of pathology of this university have given much time to the identification of specimens employed in this work.

LITERATURE

It has long been recognized that the condition of the teeth is affected by disturbances in the metabolism of the individual. John Hunter[3] said of the human body that "whichever of the connected parts be originally diseased, the teeth are commonly the greatest sufferers."

Black[4] became interested in the relation of life-periods to the character of the teeth. His studies dealt primarily with changes in the specific gravity and chemical content, and did not contribute materially to our knowledge of life-periods in relation to enamelization except in connection with syphilitic lesions.[5]

Van Kirk[6] contributed two articles describing the distribution of calciferous deposits and granular rods and the relation of cementum to enamel at the cervix. His findings were not correlated with the facts of developmental history.

Karnosh,[2] working in this laboratory, published a report based on syphilitic malformations, which has significant bearing on the problem in hand. He decided that "syphilis has a rather precipitous effect on the active enamel organ as soon as the individual is separated from the placental circulation," and that "hypoplasia of the cusps cannot be attributed to intrauterine disturbance." He believed that, after the disturbances associated with birth, the condition "gradually improves, so that the later formations of enamel, particularly those which make up the most distal portions of the cusps and lobes, are of good quality," and that "they are the accretions of the second year." He believed that deposits representing "from the second to the fifth year are likely to be subject to various maldepositions as they attempt to apply themselves to the deficient zones."

He observed further that "since exanthems are of common occurrence between the ages of 3 and 6, such acute episodes can well offer an explanation of the sharply defined hypoplastic zones and honeycomb notches seen on the labial surfaces of anterior teeth."

Karnosh's photomicrograph (Fig. 9[2]) of a supposed "mulberry molar" actually shows none of the deformities which he regards as diagnostic of such a tooth. If the incremental lines which appear about the cervix in the negative (to which I have access) had come out more sharply in the reproduced photomicrograph, the illustration could well serve as a type example of most nonsyphilitic first molar teeth.

The claim of Karnosh that calcification is uninterrupted before birth is supported neither by his own evidence nor by the

3. Hunter, John: Natural History of Human Teeth: Explaining Their Structure, Use, Formation, Growth and Diseases, Part II. Practical Treatise on Diseases of Teeth; Intended as Supplement to Natural History of Those Parts, London: Johnson, 1778, p. 4.

4. Black, G. V.: Investigation of Physical Characters of Human Teeth in Relation to Their Diseases, Etc., Dent. Cosmos, 37:353-421 (May) 1895.

5. Black, G. V.: Operative Dentistry, Vol. 1, Pathology of Hard Tissues of Teeth, Ed. 2, Chicago: Medico-Dental Publishing Co., 1914.

6. Van Kirk, L. E.: Variations in Structure of Human Enamel and Dentin, J. A. D. A., 15:1270-1280 (July) 1928. Frequency of Occurrence of Certain Structural Variations in Human Enamel, Dentine and Cementum, J. Dent. Res., 8:459-561, 1928.

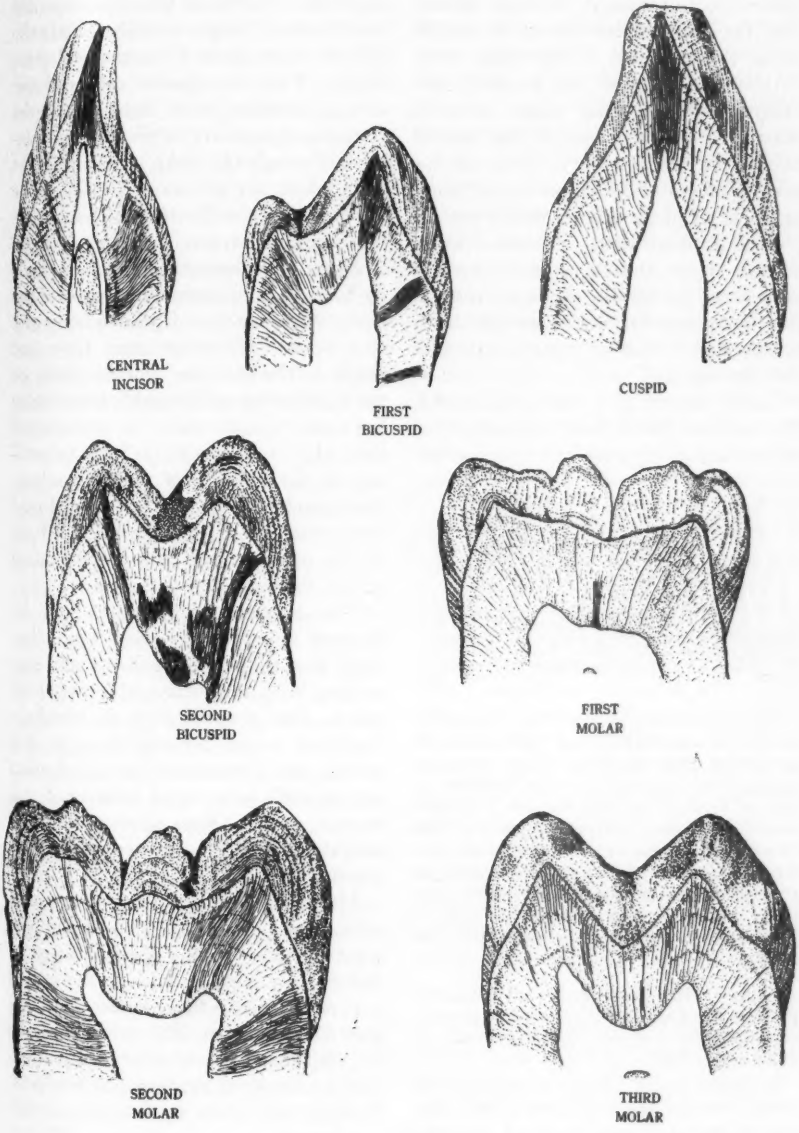

Fig. 1.—Drawings of ground sections of teeth of permanent dentition showing most common distribution of regions of comparatively less well formed enamel as evidenced by more prominent or more numerous lines of Retzius. (Compare Figure 2 and table in text.)

observations of Asper.[7] It is well known that the cusps of first molars do not all begin enamelization at the same time. (Abbott,[8] Simington and Rankin,[9] and others.) Of the three cusps shown in Karnosh's photomicrograph, the central one was the first to calcify. This cusp displays evidence of periods of calcification-arrest in all of the enamel which was deposited prior to birth. The other cusps in this figure contain a much smaller amount of prenatally deposited enamel, but the left one furnishes some additional evidence of periods of prenatal arrest of calcification.

In his sketch of a molar (Fig. 9[2]), Karnosh overemphasized the amount of enamel deposited in the first year succeeding birth. The layers which he regarded as of first year origin actually include the deposits from about 4 months to 2 years of age. That the apparent course of one or two striations in the right half of the photomicrograph are attributable to artefacts is revealed by study of the negative from which the picture was made. The left halves of the illustrations readily reveal Karnosh's error.

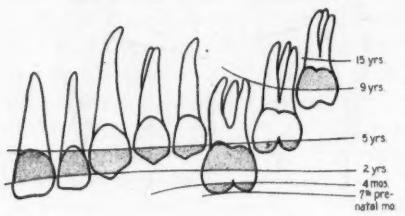

Fig. 2.—Schematic drawing illustrating periods of enamelization of teeth of human permanent dentition during which arrests of calcification (indicated by high incidence of lines of Retzius) are most common. The plain areas on the crowns represent those periods of calcification during which relatively few conspicuous lines of Retzius are formed; the stippled areas, periods during which relatively many or more conspicuous lines of Retzius are formed. (Outlines modified after Black.)

Much of the enamel considered as poor by Karnosh in his photomicrograph of the molar is, in reality, of good quality and vice versa. This error may have had origin in the fact that whereas many of the illustrations in Karnosh's article were from photographs taken by transmitted light, the "mulberry molar" was, according to the records of this laboratory, photographed with the use of reflected light (the area around the tooth is light in the print because the corresponding part of the negative was opaqued).

The photomicrograph presented by Karnosh in his Figures 3 and 9 in reality show that the months prior to and succeeding birth are unfavorable to calcification, that enamelization is relatively free from arrests between the ages of 4 months and 2 years and that calcification is frequently interrupted between 2 and 6 years of age. Both photomicrographs indicate that there were enamelization-arrests at about 1 year of age.

Mellanby[10] reported a study of ground sections of 1,036 deciduous and 266 permanent teeth. In the deciduous group, defects were most common in the second molars. In the permanent group, 94.7 per cent of the incisors, 91.1 per cent of the cuspids, 90.5 per cent of the first bicuspids, 62.5 per cent of the second bicuspids, 93.8 per cent of the first molars and 100

7. Asper, H.: Ueber die braune Retziusche Parallel-streifung im Schmelz der menschlichen Zähne, Schweiz. Vierteljahrsschr. f. Zahnheilk., 1916.

8. Abbott, Frank: Teeth of Lower Jaw at Birth, Dent. Cosmos, 35:817-827 (Sept.) 1893.

9. Simington, J., and Rankin, J. C.: Atlas of Skiagrams Illustrating Development of Teeth, London: Longmans, Green and Co., 1908.

10. Mellanby, May: Structure of Human Teeth, Brit. Dent. J., 48:737-751 (July 1) 1927.

per cent of the second molars were notably hypoplastic; and 92.1 per cent of all permanent teeth were defective. The tips of the incisors were in better condition than were other portions of their crowns.

Mellanby decided that the part of the tooth formed prior to birth and during the period of lactation has the best chance of perfect development. She believed that "the structure of the different teeth can be related (1) to the period of development; the earlier the development the better the structure, and (2) to the rate at which the tissues are laid down; the more rapid the rate the worse the structure."

Mellanby's conclusions warrant a reinvestigation as far as they pertain to permanent teeth. Since the second bicuspid is one of the last teeth to calcify and since its crown develops within a brief period, it should be a very poor one according to Mellanby's argument. Her published data show, on the contrary, that it is the best of all permanent teeth. The first molar, on the other hand, is early to calcify and sluggish in crown formation. The formation of its enamel proceeds through the latter part of intrauterine life and the entire lactation period. Surely this tooth should be a very sound one if Mellanby's conclusions are correct. Her data show on the contrary, that it is worse than the average, and Brekhus[11] has shown that it is the poorest tooth in the adult mouth.

MATERIAL AND METHODS

The findings here reported were based on ground sections of 266 permanent teeth. The specimens were collected at clinics and in the offices of dental practitioners in Cleveland, Ohio. They were preserved in alcohol or solution of formaldehyd immediately after extraction and identified. Buccolingual sections of incisors, cuspids and bicuspids, and mesiobuccal-distolingual or mesiolingual-distobuccal sections of molar teeth were prepared with the use of appropriate grinding apparatus.

The sections were examined by both reflected and transmitted light. Counts were made of the number of incremental lines crossing a unit area of enamel in various parts of the crowns. On a basis of the number of these lines in regions so located that their lines intersect the dentino-enamel junction in the occlusal, central or cervical thirds of the crowns, the collection was divided into four classes. The assignment of each tooth to one or another of these classes gave an index to the position occupied by the poorer grades of enamel in average teeth of each of the types present in the permanent dentition. The years in which this enamel was laid down were determined for incisors, cuspids, bicuspids and molars by reference to Pierce's[1] table of calcification or to the enamelization chart of Karnosh.[2] In all average cases, the years indicated as inimical to good calcification in one tooth were so indicated for all other teeth calcifying at that time. These years were therefore regarded as periods unfavorable to the deposition of good enamel. In like manner, the years were determined in which good enamelization occurs.

OBSERVATIONS

In 89.7 per cent of the central incisors examined and 83.3 per cent of the lateral incisors, the occlusal third of the crowns contained a good grade of enamel. Occasionally, there were evidences of arrested growth in the central layers of this good material. Lines of Retzius became broad

11. Brekhus, P. J.: Loss of Human Teeth, Minneapolis: University of Minnesota Press, 1928.

and numerous in the central and cervical thirds of the crown. There was also a tendency toward the appearance of exceptionally broad incremental lines in four regularly spaced intervals along the crowns of central incisors and in four or five such intervals along the crowns of lateral incisors.

Of the cuspids examined, 84.8 per cent resembled the incisors in having a fair grade of enamel at the extreme tips of the crown (cuspid, Fig. 1). Lines of Retzius which meet the dentino-enamel junction near its middle third were, however, unmistakably numerous and pronounced. The enamel was often darkened near the cervix, but marked indications of arrested growth were seldom in evidence here to the extent that they were in the layers just above.

Although the bicuspids varied greatly as to minor details, the picture presented by 82.5 per cent of the first and 76.6 per cent of the second bicuspids was an approximate reversal of that of the incisors (first and second bicuspids, Fig. 1). Incremental lines intersecting the dentino-enamel junction near its middle third were broad and markedly discolored. In the occlusal third of the crowns, incremental lines were even more numerous, often lying so close together as to impart a uniform appearance to the enamel under low powers of the microscope. In the cervical third of the crown, they were neither marked nor plentiful. The more conspicuous indications of dystrophy came slightly lower on the crowns of first bicuspids than on those of second bicuspids. (Figures 93, 94, 96, 97 and 109 in Noyes' textbook[12] show conditions that are of common occurrence in these teeth.)

The first molars presented a fourth condition. The enamel near the dentino-enamel junction in the region just over the tips of the dentinal cusps contained many incremental lines. These markings were also numerous in the cervical third of the crowns. Enamel of the middle third was relatively free from these lines, though signs of arrested development were sometimes in evidence in central accretions of this area (first molar, Fig. 1; Fig. 9 of Karnosh[2]).

The second molars were similar to the second bicuspids from the standpoint of periods of growth arrest (Fig. 1). The enamel immediately over the dentinal cusps had numerous incremental lines, while that near the necks of the teeth was relatively free from them. The only significant difference between second bicuspids and second molars was that the lines

RELATIVE DISTRIBUTION OF TEETH IN FOUR GROUPS

	A		B		C		D		Total	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
First molar	2	(12.5)	0	(0)	0	(0)	14	(87.5)	16	(100)
Central incisor	34	(89.7)	3	(7.9)	1	(2.4)	0	(0)	38	(100)
First incisor	40	(83.3)	6	(12.5)	2	(4.2)	0	(0)	48	(100)
Cuspid	3	(9.0)	28	(84.8)	2	(6.2)	0	(0)	33	(100)
First bicuspid	2	(5.0)	5	(12.5)	33	(82.5)	0	(0)	40	(100)
Second bicuspid	2	(6.5)	4	(13.3)	23	(76.6)	1	(3.5)	30	(100)
Second molar	5	(14.7)	2	(6.0)	21	(61.7)	6	(17.6)	34	(100)
Third molar	23	(85.2)	1	(3.7)	2	(7.4)	1	(3.7)	27	(100)

12. Noyes, F. B.: Textbook of Dental Histology and Embryology, Ed. 4, Philadelphia: Lea and Febiger, 1929.

were grouped closer to the tips of the dentinal cusps in the latter teeth.

In 85.2 per cent of the third molars, there was a fair grade of enamel occlusally and indications of severe developmental arrests were found near the cervices. Only 7.4 per cent of the third molars were similar to the one shown in Figure 101 of Noyes' textbook[12] as regards distribution of incremental lines.

It was apparent that the collection could be divided into the four following groups on a basis of the distribution of the lines of Retzius: A. Teeth with relatively good enamel occlusally and a relatively poor quality of enamel cervically. B. Teeth with a relatively poor grade of enamel in the middle third of the crown and with relatively good enamel in the occlusal and cervical portions. C. Teeth with relatively poor enamel in the occlusal third of the crown and with relatively good enamel elsewhere. D. Teeth with relatively poor enamel occlusally and also in regions near the necks, but with few indications of arrested growth in the intervening portions.

The accompanying table indicates the relative distribution of incisors, cuspids, bicuspids and molars with regard to the foregoing groups and gives numerical and percentage indications of this distribution.

COMMENT

The only enamel deposition which occurs in permanent teeth during the last month prior to and the first four months succeeding birth takes place in the first molars. Since this enamel is usually heavily marked with incremental lines, we may regard these five months as unfavorable for calcification.

All enamel deposition which occurs between 4 months and 2 years of age takes place in the occlusal third of the incisors, over the extreme tips of the dentinal cusps of cuspids and in the central layers of the crowns of first molars (Fig. 2). In the great majority of cases, these regions all contain enamel of relatively good quality. Hence, there is reason to believe that this period is relatively favorable for calcification.

Most areas of poor enamel to be found in average incisors, cuspids, bicuspids and second molars and the area of poor enamel in the cervical third of the crowns of first molars occur in those parts of the crown which calcify during the third, fourth and fifth years (Fig. 2). Within this period, in average cases, few regions calcify which are not heavily marked with incremental lines. The years from 2 to 5 may therefore be regarded as especially prone to poor enamelization.

Enamelization goes on in the crowns of cuspids, bicuspids, second molars and third molars between the ages of 6 and 9 inclusive. None of the accretions representing these years are heavily marked with incremental lines in average cases (Figs. 1 and 2). These years may therefore be regarded as favorable to enamel deposition.

The third molar is the only tooth in which the enamel is calcifying after the age of 10 (though much disagreement exists as to the time when it calcifies). This tooth bears many indications of periods of arrest in calcification near the cervix. It may be concluded, therefore, that among the last years in which crown formation takes place, there are years (probably from about 12 to 13½) in which disturbances in enamelization are relatively common.

The occasional indications of arrested growth seen in accretions of about 1 year of age in incisors and first molars may possibly represent nutritional episodes associated with weaning. There is probably no other incident of regular occurrence at

that age to which significant dystrophies might be attributed.

The regularly spaced areas of wide incremental lines sometimes seen in anterior teeth may represent winter months. This belief is supported by our knowledge as to the effect of sunlight on dentition and seasonal differences in sunlight impinging on the earth. It is also supported by facts as to the seasonal differences in consumption of certain foods.

Attention has been directed to the fact that Karnosh's article[2] indicates the existence of the unfavorable period which prevails in the third, fourth and fifth years of life. The statements previously quoted from Karnosh show that he may have recognized these three periods vaguely and knew the effect that each one has on the teeth. Attention has also been called to the fact that his evidence supports the belief that disturbances sometimes occur at about 1 year of age. Mellanby's statement that a high proportion of hypoplasias exist in deciduous second molars, and her observation that good enamel occurs in the tips of incisors and that poor enamel is found elsewhere in the incisor crowns, indicates that she vaguely recognized three periods of cyclic change in enamelization also.

SUMMARY

The magnitude and distribution of incremental lines in the permanent dentition of man offer evidence of cyclic changes in the quality of enamel accretions. These changes are associated with specific ages in the fetus, infant and child. From the date of incidence of enamelization in permanent teeth until the baby is about 4 months old, the process is subject to comparatively marked disturbance. Circumstances prevail which are favorable to calcification between the ages of 4 months and 2 years. A period which is unfavorable to calcification covers the third, fourth and fifth years of life. Between the approximate ages of 5 and 10, the accretion of enamel is relatively unhampered. At about the age of 10 or later, a period begins which is unfavorable to calcification. This lasts until all crowns are formed.

The regularly recurring areas of broad lines of Retzius that are sometimes evident in incisor teeth may represent the regions formed during winter months.

Broad incremental lines sometimes evident in the tips of the central incisors and in deposits of enamel of first molars which represent the accretions of about 1 year of age are possibly caused by nutritional disturbances associated with weaning.

In the light of the foregoing facts, it seems that the suggestions of Cecil and Miner[13] as to the feeding of infants, children and adolescents deserve the attention of students of dietetics who are interested in the welfare of the teeth.

13. Cecil, R. L., and Miner, L. M.: Interrelation of Medicine and Dentistry, J. Dent. Res., 10:137-157, 1930.

STUDIES IN PROSTHESIS*

By M. M. HOUSE, D.D.S., F.A.C.D., Whittier, Calif.

THE title, "Studies in Prosthesis," permits of rather a broad discussion, which was deemed advisable in covering, in a limited way, a few factors that, although intensively studied for at least three generations, are still confused and chaotic in the minds of our profession.

There are many reasons for this mental confusion. A few of these it seems advisable to consider as a preface to the main factors in this presentation.

Think of the differences of temperament, age, health, social position of our patients and their exacting requirements plus the variability in the vitality and tolerance of the oral tissues; then, ask yourself if there is any arbitrary routine procedure that will fulfil the desires and necessities of all.

Consider also the various temperaments of the dentists, their knowledge, experience, ideals, etc., and you will realize why the scientific knowledge available at present is not more generally applied in dental practice.

Success means the attainment of a proposed object. The objective in our present discussion would be to render to our patients the highest degree of health service, including oral, mental and systemic health. If we hope to achieve such an ideal, it is evident that stressing the importance of one factor above all others in the long list of intricate fundamental and technical details could result only from ignorance, overenthusiasm or selfish interest on the part of a dentist.

Dentists' ideas vary decidedly as regards standards and what constitutes success. Patients likewise have different conceptions of successful dental service, varying with their understanding of the problems to be met and influenced in a large measure by their health, temperament, social standing, etc. On final analysis, it becomes a matter of the mental, physical and tissue tolerance of the patient, plus the knowledge, skill and ideals of the dentist, which will forever leave the problem of successful dental service open for discussion in our profession.

This does not mean that it will in any way leave the subject as an unsolved problem; for the work of the many past and present investigators has removed the element of guesswork from the subject and made of it a work of fundamental science. If the knowledge available at present is applied, a correct diagnosis and prognosis can be made of each case; but this basic fundamental to successful dental service is grossly neglected by the majority of dentists. The correct designing of restorative appliances is impossible unless all factors pertaining to the case are carefully considered.

Much has been written regarding mandibular movements and dental occlusion, that of both the natural dentition and artificial substitutes. There are many

*Read before the Section on Full Denture Prosthesis at the Seventy-Second Annual Session of the American Dental Association, Denver, Colo., July 23, 1930.

conflicting opinions regarding this subject, because of the different angles from which it has been approached by different investigators and the variety of conclusions that they have reached.

Some have based their studies on the physical and anatomic factors involved, while others have worked out theories of these principles of occlusion and applied their interpretations to the construction of appliances and articulators.

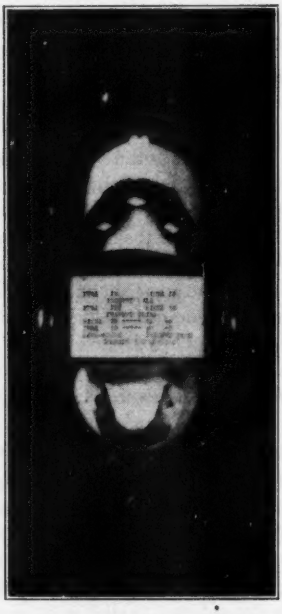

Fig. 1.—Registration rims made of modeling compound on vulcanite baseplates. The occlusal surface of the bite rims were formed to the curve of a 4-inch radius. Three tracing studs were placed in the maxillary bite rim, with which the patient chewed the registrations in the mandibular bite rim, under the functional forces of mastication. Readings taken from the registration are as follows: left protrusive condylar angulation, 39 degrees; left lateral condylar angulation, 30; right protrusive condylar angulation, 38; right lateral condylar angulation, 47; left lateral shift (Bennett movement), 12.5; right lateral shift (Bennett movement), 20; left horizontal incisive path, 15; right horizontal incisive path, 15.

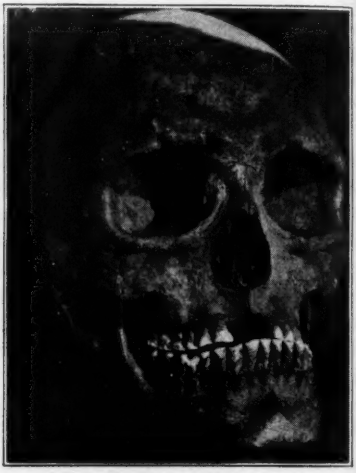

Fig. 2.—Skulls with perceptible attrition on occlusal surfaces of teeth and composite curves of occlusion, due to variability of angulations of mandibular movements as shown in Figure 1.

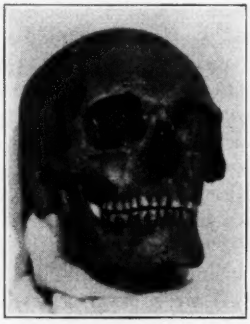

Fig. 3.—Skulls with perceptible attrition on occlusal surfaces of teeth and composite curves of occlusion, due to variability of angulations of mandibular movements as shown in Figure 1.

In order to clarify the foregoing, it seems advisable to define principle and

theory. Webster defines principle as "a source or origin or that from which anything proceeds; basic or fundamental," and theory as "a speculation or hypothesis: "the general or abstract facts, real or assumed."

Investigators have found it necessary to apply the science of geometry, mathematics and engineering to the problems involved, in designing and constructing mechanical devices and articulators that will reproduce the movements of the mandible, as interpreted from their findings.

In order to make registrations of mandibular movements, it has also been necessary to design ways and means in the form of different technics and appliances, and to transfer them with casts to an articulator. This work has resulted in the development of many devices and methods of application, which have been taught by the various designers according to their theories, interpretations and findings.

According to the late George H. Wilson's analysis of the theories and methods of application, two different schools of thought have been developed: (1) those who believe that the teeth are the guiding factors of the positions and movements of the mandible, owing to the tactile sense of the tooth cusps and their angulation of guidance in function; (2) those who believe that the condyle heads functioning in the glenoid fossae are the controlling factors of guidance in the movements of the mandible.

An analysis of the various studies and investigations shows conclusively that, in each case, but a part of the whole truth has been considered.

There are four definite factors in the government and control of movements of the mandible in all normal cases with natural dentition: the muscles and ligaments, the right and left condyles functioning in the glenoid fossae and the teeth when in contact. We must distinguish between general movement of the mandible as a whole and the movement of specific points of the mandible or associated with it; otherwise, no clear conception is given. These are demonstrable facts. If the teeth were the only source of guidance in the mandibular movements, the mandible could function in all ranges on flat occlusal bite planes without losing contact

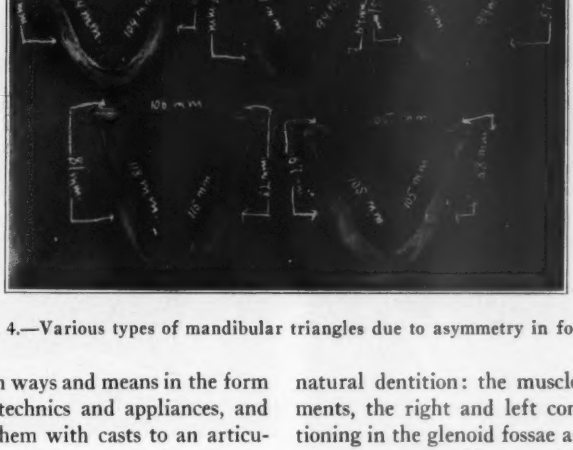

Fig. 4.—Various types of mandibular triangles due to asymmetry in form.

with the bite planes in any of the ranges of movement.

Tracings of mandibular movements show that the movements of each specified point are arcs and curves and that the angulations and arcs of movement of these points are different on two sides in the same individual and vary decidedly in all individuals.

Fig. 5.—Both anterior and posterior views of heads of condyles. Their variability and asymmetry of form account for some of the variations in the angulations of mandibular movements.

Figure 1 shows an interesting registration in proof of the foregoing. The left protrusive condylar angulation is 39 degrees. The left lateral path is 30 degrees. This shows that the downward angulation of the lateral path is 9 degrees less than that of the protrusive path.

The right protrusive condylar angulation is 38 degrees. The right lateral path is 47 degrees. This shows that the downward angulation of the lateral path is 9 degrees greater than that of the protrusive path. The left lateral shift is 12.5 degrees and the right lateral shift is 20 degrees. The right and left incisal paths in

Fig. 6.—Both anterior and posterior views of heads of condyles. Their variability and asymmetry of form account for some of the variations in the angulations of mandibular movements.

the horizontal plane are 15 degrees each. It will readily be seen that in endeavoring to have the patient chew in the curves of occlusion on bite-blocks, the most extreme type of a composite curve would be made, which would not permit of correctly balanced contacts in either the centric lateral or the protrusive occlusions. The curves

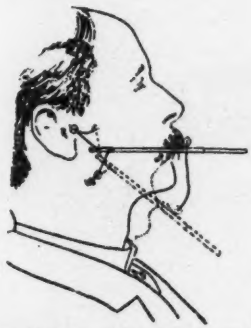

Fig. 7.—Photographic method used by C. E. Luce in proving variations in angulations of mandibular movements.

Fig. 8.—Photographic method used by C. E. Luce in proving variations in angulations of mandibular movements.

on these bite rims are made from a spherical plate of a 4-inch radius. You will notice from the extremes in this registration that the tracing studs have taken up the variables in the condylar angulations in the various positional relations of the mandible. Vulcanized biteplates were used for the purpose of rigidity and accuracy of adaptation to the ridges. The tracings were made under the normal pressures of masticating function, which registered the resilient effects of the tissues, thereby giving equilibrium to the dentures in function. This case clearly demonstrates the impossibility of the patient's ever being able to effect a balanced occlusion in the finished dentures in the mouth by chewing carborundum.

Figures 2 and 3 show two skulls, illustrating the effects of perceptible attrition

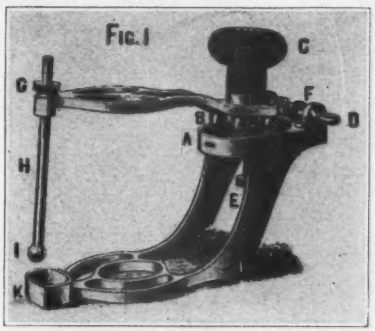

Fig. 9.—Articulator designed by C. E. Luce for reproducing angulations of mandibular movements, by molding in a plastic material.

on the teeth, and clearly demonstrate the composite curves of occlusion.

All intra-oral, extra-oral and checkbite methods of registration prove conclusively that the condyle inclinations in the lateral or masticating paths of movement vary on the two sides. They also show that the angulations of condyle movement in the protrusive range is different in the same individual on the two sides and they are seldom the same as the lateral inclinations on the same side, and the incisal paths in the horizontal plane vary proportion-

ately with other angulations of movement.

Figure 4 shows various types of mandibular triangles due to asymmetry in form. The side measurements were taken from the gonion to the center of the articular surface of the condyle heads, for other asymmetric forms of the mandibles, account for some of the variations shown in the angulations of mandibular movements.

Cases are on record in which the heads of the condyles have been removed owing to injury or ankylosis of the temporo-

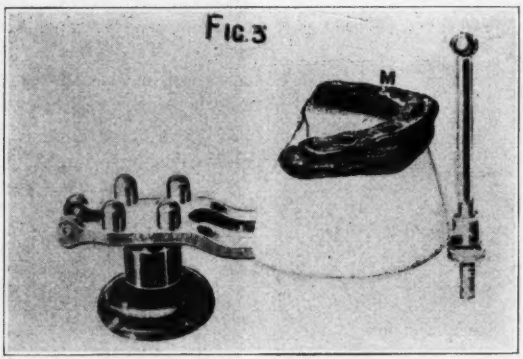

Fig. 10.—Traced record of functional movements of mandible in occlusal surface of maxillary bite rim.

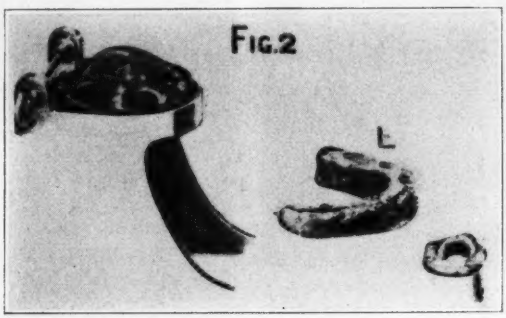

Fig. 11.—Lower bite rim registration with the tracing studs in place; also incisal cup and upper container with registrations reproduced in plastic material.

the purpose of showing the variation in lengths of the ascending rami.

Figures 5 and 6 show both anterior and posterior views of the heads of the condyles. The comparative variations in the condyle heads of each mandible, plus mandibular joints. This has not in these cases prevented functioning in the various ranges of movement with the natural dentition or artificial dentures; which proves that the muscles, ligaments and teeth with the condyle heads removed

permit both functional use and control of the mandible, though the angulations of movement may be different.

The overbite of the anterior teeth and the cusp depth of the posterior add a vertical element of movement in both the lateral and the protrusive ranges. This varies in proportion to the angulation and cusp depth of the posterior teeth, plus the degree of overbite and cuspid guidance of the anterior teeth.

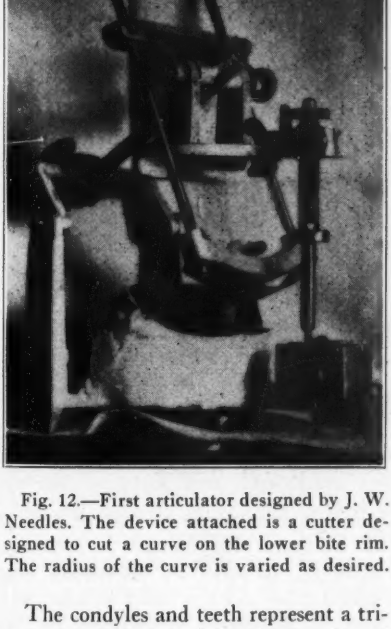

Fig. 12.—First articulator designed by J. W. Needles. The device attached is a cutter designed to cut a curve on the lower bite rim. The radius of the curve is varied as desired.

The condyles and teeth represent a tripod, the teeth being the third point of support in the vertical dimension. The muscles furnish the power and direction of movement and the ligaments control the limit of the same. It therefore becomes purely a problem of solid geometry, in which three points are required to establish a position. The early studies of the temporomandibular joint were made by anatomists. Attention was called to its form and function in harmony with the anteroposterior curve of the teeth by Count von Spee, from whom the curve of Spee[1] has its name.

The work of Bakewill,[2] Luce,[3] Walker,[4] Bennett,[5] Christensen,[6] Gysi[7] and others conclusively proves that there are great variations in the angulations of the movement of the mandible in all cases.

Figures 7 and 8 show a photographic method that C. E. Luce used in proving the variations in the angulations of mandibular movements in 1889, at the Harvard Medical School.

Figures 9-12 were taken from *Ash's Monthly*, of November, 1911, a paper by C. E. Luce, now of Stuttgart, Germany, published in the *Dental Review*. Figure 9 shows an articulator on which Dr. Luce obtained a patent, Nov. 28, 1911. It is a three-dimensional instrument designed

1. Wilson, G. H.: Dental Prosthetics, Ed. 4, Philadelphia: Lea and Febiger, 1920; chap. 1.
2. Bakewill, F. H.: The Best Form and Arrangement of Artificial Teeth for Mastication, Tr. Odontol. Soc. Great Britain. Vol. 5.
3. Luce, C. E.: Movements of Lower Jaw, Dent Mirror, 2:97-99, 1891; Movements of Lower Jaw, Boston M. and S. J., July, 1899; Mandibular Movements and Articular Question, Ash's Quart., 1911, pp. 921-31.
4. Walker, W. E.: Prosthetic Dentistry; Glenoid Fossa; Movements of the Mandible; Cusps of Teeth, Dent. Cosmos., 38:34 (Jan.) 1896; Movements of Mandibular Condyles and Dental Articulation, ibid. 38:573 (July) 1896; Facial Line and Angles in Prosthetic Dentistry, ibid., 39:789 (Oct.) 1897.
5. Bennett, N. G.: Movements of the Mandible in Relation to Prosthetics, Brit. Dent. J., 14:217-227 (Feb. 1) 1924.
6. Christensen, Carl: Rational Articulator, Ash's Quart. Circ., 1901; Problems of the Bite, Dent. Cosmos, 47:1184 (Oct.) 1905.
7. Gysi, Alfred: Essentials to Masticating Efficiency in Artificial Denture, Dent. Digest, 27:19-24 (Jan.) 1921.

to reproduce the functional movements of the mandible with plastic molded records. Figure 10 shows a traced record of the functional movements of the mandible in the occlusal surface of the maxillary bite rim. Figure 11 shows the lower bite rim registration with the tracing studs in place, also the incisal cup and the upper container with the registrations reproduced in plastic material. It will readily be seen that this method is not only logical, but also correct in its transfer and application to the articulator for reproducing the functional movements of the patient. It makes a simple form of registration and reproduction of the mandibular movements in the articulator. It has the same objection as the other mechanical and three-dimensional articulators that have since been made, without a hinge axis of opening; namely, that the addition of an overbite for esthetic reasons or the addition of posterior teeth with cusps cannot be made conveniently.

John W. Needles,[8] formerly of Pueblo, Colo., now located in Los Angeles, Calif., worked out a method comparable to that of Dr. Luce for the registration of mandibular movements, though he knew nothing of Dr. Luce's work. Like other investigations in this subject, he found it necessary to work out a mechanical device that would embody the principles and movements of the mandible according to the interpretations of his findings. He worked on the principle that the movements of the mandible are spherical, a principle comparable to that of George S. Monson. He deemed it necessary, however, to have an instrument that would trace and reproduce in controlled form the movements of the mandible. He devised an incisal guide control for his

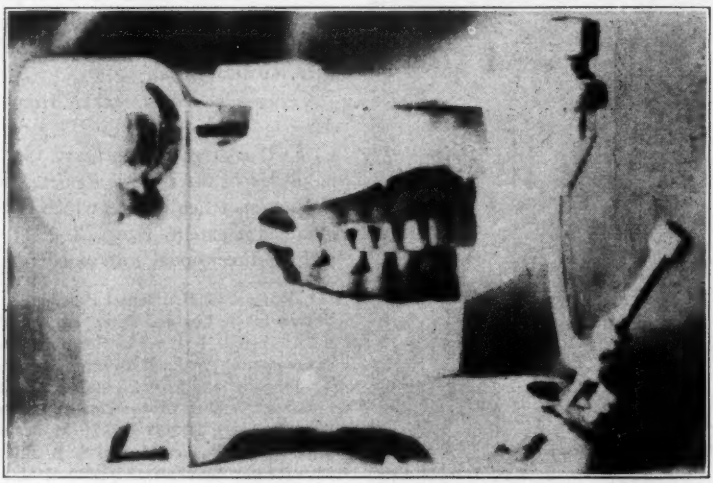

Fig. 13.—Second articulator designed by J. W. Needles.

8. Needles, J. W.: Mechanics of Spherical Articulation, J. A. D. A., 9:866-881 (Oct.) 1922; Practical Uses of the Curve of Spee, ibid., 10:918-927 (Oct.) 1923; Mandibular Movements and Articulator Design, ibid., 10:927-935 (Oct.) 1923.

instrument for reproducing these movements, in both the horizontal and the vertical planes.

Figure 12 shows the first articulator designed by J. W. Needles; Figure 13 shows the second articulator designed by him, and Figure 14, the intra-oral functional registration method developed by him.

Dr. Needles presented this work to the National Society of Denture Prosthetists, at Milwaukee, Wis., in 1921. Intensive studies and thorough tests have been made with this form of registration in both partial and fully edentulous cases.

Fig. 14.—Intra-oral functional registration method developed by J. W. Needles.

These tests have proved the soundness of the work of both Drs. Luce and Needles, and have proved this method of intra-oral three dimensional, functional registration to be simple and efficient. It gives a permanent record of all possible occlusal relations of the mandible to the maxilla and provides a simple method of reproducing these movements in any fully adjustable articulator. The articulator adjustments may then be made and the degrees of the angulations of the mandibular movements recorded. The registration is made under the normal pressures and functions of mastication, thereby giving equilibrium to the restoration in use. Equilibrium, as applied, means a state of balance between two opposing forces or actions. The tracing studs are so constructed that they give vertical resistance when used with a modeling compound tracing rim. When placed at the incisal and molar areas in the occlusal bite rim, they register the vertical variations and resilient effects of the tissues under the registration plates.

There are other decided advantages of this method of registration. In extreme cases of long standing, when malposition of the mandible has become an habitual malfunction, the fatiguing of the muscles by constant chewing with the registration studs until all intermediate ranges of occlusion have been finished redevelops the normal function and places the mandible in the correct functional centric relation to the maxilla. This method of registration definitely differentiates the functional centric occlusion from a forced retrusive occlusion. When the excursion of the mandible is made from functional centric to right or left lateral occlusion, the gothic arch tracings will be straight lines as far as the eye can determine. In cases showing an extreme lateral shift of the mandible, the gothic arch of the anterior tracing may show slight curves, but the posterior gothic arches will appear as straight lines. If the gothic arches show perceptible curves in edentulous cases, this proves definitely that the mandible is moving in a protrusive lateral range. The foregoing is true of registrations made of partially edentulous cases in which the teeth are freed from contact. In registrations made with the teeth in contact, perceptible curves in the gothic arches definitely prove malocclusion, or that there is a definite point of interference in the occlusion of the teeth.

These tests have also proved the value of the claims made by Dr. Gysi regarding the gothic arch and its value in registering the incisal horizontal positional relations of the mandible to the maxilla.

Figure 15 shows tracings taken of my own mouth. I have thirty-two perfect teeth with fine alinement and good cusp forms, with a minimum amount of wear. Tracing *1* was taken with the teeth freed from contact; tracing *2* was taken with the teeth in contact in all functional ranges.

Note, in the base of tracing *2*, the mortar and pestle effect of the cusp relations or the triturating range and freedom in the centric occlusion.

These tracings show definitely the functional centric occlusion in the polished base of the apex of the gothic arch, which distinctly differentiates between functional centric occlusion and a forced retrusive centric occlusion.

Figure 16 shows casts of my teeth with tracing *1* in place.

Fig. 15.—*1*, tracings of mandibular movements of author with teeth freed from contact; *2*, tracings of mandibular movements of author with teeth in contact. The cusp relations of the teeth have a mortar and pestle effect in the centric or triturating range, and there is freedom of occlusion in centric occlusion. The similarity of the gothic arch tracings *1* and *2*, shown on the inset, is evident. *1*, graphic record made with author's teeth freed from contact; *2*, a graphic record made with teeth in functional contact.

Of the drawings in the center, *1* shows the gothic arch with the teeth freed from contact, as compared to *2*, the gothic arch with the teeth in contact. Observe the base of tracing *1* with the teeth freed from contact as compared with the base of tracing *2* with the teeth in contact.

Figure 17 shows a patient, Mr. R., 70, who had a full maxillary denture opposing fixed bridgework. The case was placed in the mouth twelve days after the extraction of ten anterior maxillary teeth, with pathologic areas. Figure 18 shows the tracings made of the case. Owing to

the condition of the other teeth in the maxillary arch, the patient had been masticating with the right upper cuspid for a number of years. He had developed a right protrusive malposition of the mandible. When the muscles were fatigued in making the registration, and he had registered functional centric occlusion, the mandible would move backward 9 and 3 mm. to the left, from the habitual malposition. Attached to the condyle rods of this instrument are two tracing needles and attached to the base are two adjusted tracing plates on which can be seen traced diagrams showing the movements of the two sides of the articulator. On the right diagram, the form of movement on the articulator is reproduced from the registration. On the left diagram, the form of movement is produced on the articulator from the registration, which shows a 25 degree lateral shift of the mandible, whereas the right diagram shows no lateral shift. Added to this instrument is a mechanical incisal control, which reproduces accurately the rotation centers of mandibular movements as recorded from the tracings. Tests have proved that instruments made without an incisal control for the rotation centers of mandibular movements do not reproduce accurately the lateral shifts, because they are reverse arcs in movement.

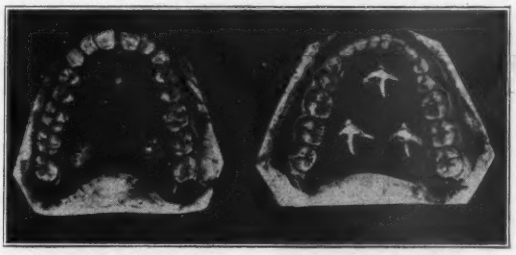

Fig. 16.—Casts of author's teeth with tracing *1* in place.

Figure 19, left, shows casts of the case taken the day after completion; right, casts of the case made recently after five and one-half years of service. The case was completed in February, 1925. There has never been an adjustment made for soreness or correction of the occlusion. The occlusion was ground in on the articulator with the rotary occlusal grinder in harmony with all angulations of function as recorded from the registration. A deep bite mold of posterior teeth was used on the maxillary denture, and the lower bridgework was carved to fit the opposing teeth. Another fact of special interest in this case is that all socket elevations in the impression were scraped out for the purpose of stimulating regeneration of bone and the forming of a smooth ridge. The ridge is so formed that it is perfectly adapted to the plate as made and the case has never been rebased.

Figure 20 shows a picture of my father, who is 77 years of age and in good health. This case is of special interest, because he has chewed tobacco since he was 12 years old. The attrition on his natural teeth caused the removal of the majority of them, both maxillary and mandibular. I made him a fixed bridge in units of fourteen teeth above and fourteen teeth below, in 1910. I raised the occlusion 10

mm. and made the posterior teeth with castings of a hard gold alloy. He chewed these down to approximately the previous state of his worn occlusion in eighteen months. I have since made him four complete cases, all with porcelain occluding surfaces and the fifth case, which he is wearing now, will probably last him another six months. Figure 21 shows the casts and registration plates from which the latest case was made. An interesting fact in his case is that, for the past nine

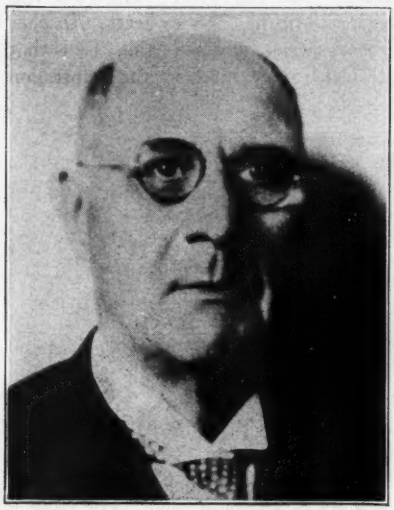

Fig. 17.—Patient, aged 70, with full maxillary denture opposing fixed bridgework.

years, he has had only the first bicuspid and second molar on the left side of the mandible and he has never been able to detect any undue strain on them since the loss of the cuspid on that side. The case was made with the same technic used in Mr. R.'s case, and there has never been an adjustment made of any nature since it was placed in his mouth. Figure 22 shows casts of the completed case made the day the bridges were set. Figure 23 shows the last two cases as they were when removed from his mouth. There is a lateral shift of 25 degrees on the functioning side of his jaw, and the upper cast of one case will function with either lower, or vice versa.

The denture he is now wearing was made without an overbite of the anterior teeth, for the purpose of testing the form of wear that would take place as compared with the cases that were made with a medium overbite. The same type of overbite and form of wear has taken place in this case as is shown in his previous cases. This demonstrates conclusively the individuality of the functional angulations and movements of the mandible.

The giving of case histories seems to be desired by many as proof of the success of some method or system. I could cite many histories showing successful results, in both fixed and removable restorations, where functional registrations were made. Experience and tests have proved that the value of this method of intra-oral functional registration cannot be overstressed. Case histories mean nothing, unless each step in the sequence of our work has been given equal importance and accuracy from the beginning of diagnosis to the completion of the case, including the postoperative treatment required. My one ambition and desire in dentistry has been to see the day that I could make a diagnosis, prognosis and design of a case and, when it was completed, see it work out as I had planned. This is the reason I have studied intensively the work of different investigators and have made thorough tests in the application of their work. My final conclusion regarding the same is that the basic and fundamental facts pertaining to jaw movements have been proved. The registration of the mandibular angulations and movements is

necessary for all prosthetic restoration cases, if the most ideal results are to be obtained.

It is necessary for us, as practitioners, to eliminate all empiric methods and steps in the sequence of technic and application in the construction of our work, if we are interested in highly efficient results.

the assistance and collaboration of its members, to make a complete survey and study further the problems of mandibular movements.

Many appliances were developed for testing in different ways the positional and functional movements of the mandible. Articulators were constructed and

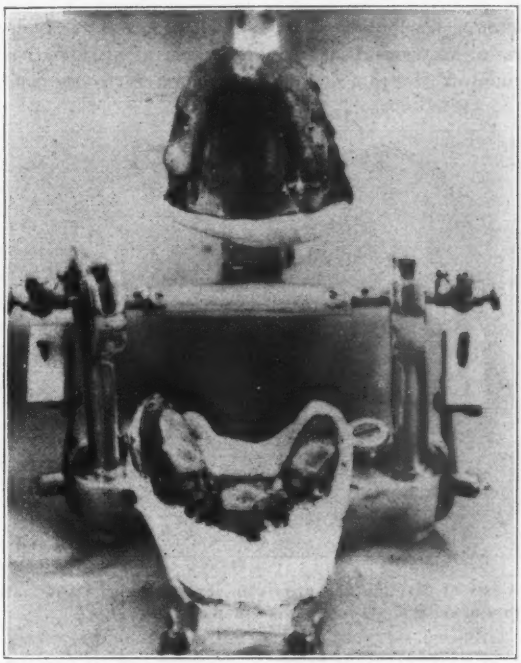

Fig. 18.—Tracings of mandibular movements of patient shown in Figure 17.

In 1925 we had the good fortune to have Dr. Needles associate himself with our work at the Deaner Institute in Kansas City, Mo. We had a machine shop with Mr. A. L. Hanson, who is an engineer and machinist, in charge. Dr. Needles was given a free hand and all the facilities of the institution, including

tests were also made of the various adjustable and semi-adjustable articulator mechanisms that were available. (Fig. 24.) This work finally resulted in the development of a hinge axis, three-dimensional articulator, incorporating the use of the Needles incisal guide unit. Tests so far made with this instrument have

proved its efficiency in tracing and reproducing registrations made of mandibular movements. (Fig. 25.)

Figure 26 shows the tracing device attached to the natural teeth of the mandible and the maxilla; also the tracings made of the protrusive condylar angulations in conjunction with a record of the full opening and closing movement of the mandible, without protrusion and in extreme protrusion. The small loop in the center of the anterior tracing shows an opening and closing movement of the mandible in a semiprotrusive range. Figure 27 shows an enlarged record of the tracings shown in Figure 26.

Figure 28 shows the upper appliance that was attached to the maxillary teeth for holding the tracing targets. It also shows the tracings of the movements of the right and left condyles in both the lateral and the protrusive ranges. Figure 29 shows the lower appliance with the center stud support and tracing needles which was attached to the mandibular teeth for recording the mandibular movements.

Figure 30 shows a Gysi facebow in conjunction with a pointed bar attached to the upper cast, which was also used in measuring degrees and angulations of condyle movements in various mandibular positions by means of wax checkbites.

Figure 31 shows another design of tracing and recording device made with double gothic arch tracing needles and an adjustable center stud support. There are three adjustable studs and a tracing needle on each side for registering all angulations of the mandible. A facebow with unilateral adjustments was attached to this apparatus and other mechanisms, for the purpose of testing the difference in condyle positions during light contact and heavy pressures. This was for the purpose of determining the effects of resiliency in the mandibular joint, in natural dentitions, and also the resilient effects in partially and in fully edentulous cases. It was found, after the axis of opening

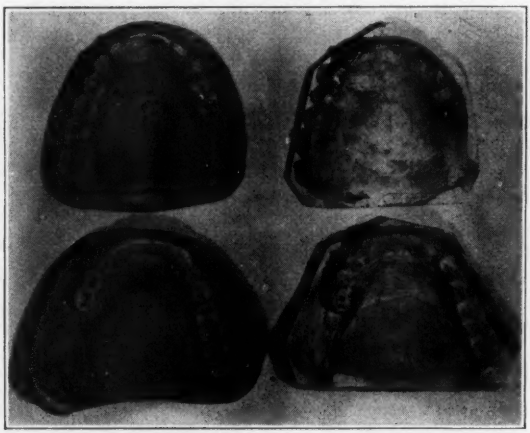

Fig. 19. Left: Casts of case the day after completion. Right: Casts made recently, after five and a half years of service. (From patient shown in Fig. 17.)

was located, that the point of the condyle bar of the facebow would move in varying degrees comparable with the amount of resiliency and pressure exerted on the teeth or bases when they were in centric or eccentric occlusion.

This test may be made by any one with a natural dentition by gently closing the jaws until the first contact of the teeth is felt. By increasing the pressure gradually until heavy pressure is experienced, one will notice that increased numbers of the teeth contact until heavy pressure is felt in the anterior teeth in centric occlusion.

Fig. 20.—Photograph of author's father, aged 77, wearing his fifth denture. (Compare Fig. 21.)

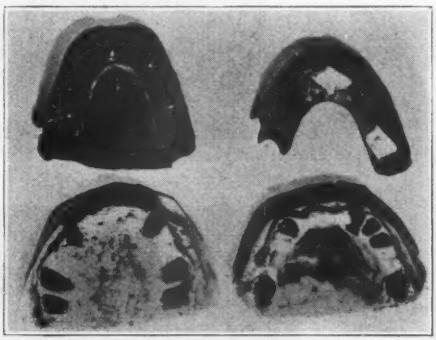

Fig. 21.—Casts and registration plates from which the fifth case (Fig. 20) was made.

This should demonstrate that equilibrium of restorations can best be made by registering the mandibular movements under the normal pressures of masticating functions, thereby taking up the resilient effects of the tissues involved.

Studies and tests were also made of the reverse curves of occlusion. There is nothing in the form of the anatomic structures that shows a possibility of there being reverse curves in the occlusion of the teeth. Tests with edentulous cases showed that reverse curves, when recorded, were due to the inaccuracy in adaptation of the base plates and malpositions of the mandible. Observations made of a large number of skulls with full complements of teeth showed no perceptible change in the form of the glenoid fossae, or heads of the condyles, though there was a perceptible variation in the degrees of attrition on the teeth. Tests made with the addition of third molars to artificial restorations have proved them to be very advantageous to the balancing of the occlusion and added much comfort to the wearing of the dentures. A careful study of the location of the third molars and their relation to the forces of musculation in normal cases will reveal their importance and proof of the foregoing.

Dentists talk in terms of one one-thousandth of an inch in the measurement of mandibular movements and the transferring of casts to articulators, and stress these points to the extent of great confusion in the minds of the profession in general. They seem to give no consideration to the fact that we are working with resilient anatomic structures that it is im-

possible to measure to such fine degrees of accuracy. Many steps in the technic and the materials used would prevent such accuracy being obtained in the construction of artificial restorations.

variations in the size, form and relation of the maxilla and mandible, should prove to any unbiased mind that the masticating function of each person is a law unto himself.

Fig. 22.—Left: Casts made of completed case the day bridges were set. Right: Casts made from case after four years of service.

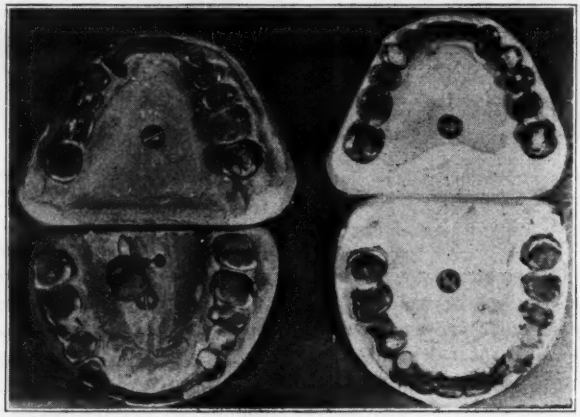

Fig. 23.—Two cases as they were when removed from mouth of author's father (Fig. 20), each having been used about four years.

A study of fine natural dentitions and the variations found in the occlusal forms of the teeth due to attrition, plus the

These studies show conclusively that in Nature's design, a system of freedom in the occlusion of the teeth and also a

resilient tissue protection has been perfected which allows for a great limit of tolerance and trauma, as a prevention to destruction and disease. Without these provisions of Nature, dentistry as practiced would be an impossible profession.

the various adjustments should control and limit the movements to those which are to be reproduced. It should be of a size and weight convenient for use and be rigid and accurate in construction. The range of its movements should be equal

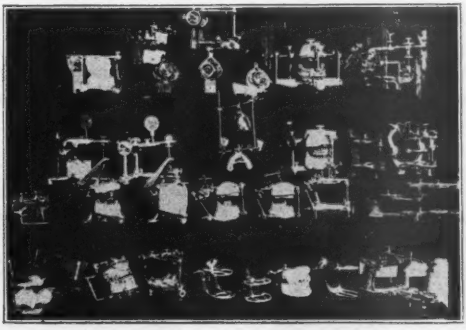

Fig. 24.—Various types and makes of articulators and some other appliances that were used and tested with technics designed and recommended for each.

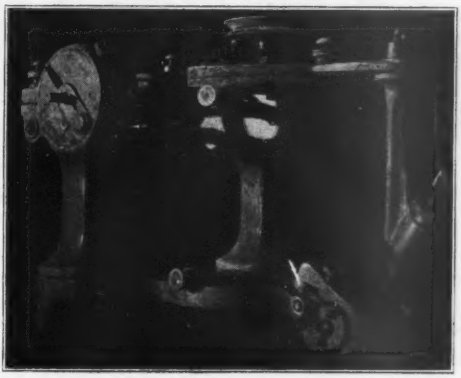

Fig. 25.—Fully adjustable, hinge axis, three dimensional articulator, built in 1927.

ARTICULATORS

Much has been written about articulators. An ideal articulator would be a fully adjustable, three-dimensional instrument. It should be simple in design and to that of the human jaws. It should be provided with a hinge axis of opening to accommodate the cusp forms and bite depths of the posterior teeth and the overbite of the anterior teeth. The accuracy

and limitations of any articulator may be determined by the use of the split cast method devised by Dr. Needles. (Figure 33.)

It was found by the use of this method in testing the accuracy of articulators that, in order to check accurately the component positions of the mandible to the maxilla in natural dentitions, having records comparable with the angulations, as shown in Figure 1, all fully adjustable three-dimensional articulators must be adjusted to each component position.

In prosthetic restorations, the correct grinding and freeing of the occlusion of the teeth in the segregated centric and eccentric relations in harmony with Nature's principles removes interference in the component movements of the mandible. The compensating curves are therefore perfected for correctly balancing the occlusion of the teeth in harmony with the functional relations and movements of the mandible.

This permits of synchronizing the teeth and balancing the occlusion with all of the functional component movements of the mandible and prevents the resultant effects of the composite curves, as shown in Figures 2 and 3.

Tests have shown, in endeavors to have patients correct the occlusion by chewing carborundum, that they will, owing to conscious effort, chew in but a limited number of the positional and functional ranges of the occlusion. This fact, combined with the compromising effects of the tissues under residual bearing appliances, prevents the possibility of balancing and harmonizing the occlusion of the teeth with the normal functions of mastication.

Fig. 26.—Appliance as it appeared on face for making graph records of all mandibular movements.

Fig. 27.—Right and left condyle tracings and opening and closing tracing of mandible in full protrusion and retrusion. The small tracing in the center is a component movement incorporating a semiprotrusive and opening movement of the mandible.

TECHNICS

A technic must be correct in principle, each step in the sequence mechanically accurate and its application harmonious with the fundamental factors involved. A charted record should be made of all adjustments of the articulator, in addition to all other details of the case. Three fundamental factors are to be considered

when setting up the teeth: (1) esthetics, which represents the setting of the teeth for the finest harmony of expression; (2) the alinement in the arch and correct relation to the ridges for resistance to stress and leverage; (3) the compensating curves as required for balancing the occlusion in the various ranges of function, as recorded from the case.

The twelve anterior teeth are set according to the relations desired for esthetics and resistance to stress and leverage in function. When the anterior teeth are set as desired and the condyle readings are set according to the protrusive records, the teeth are moved to an end-to-end relation, at which time the vertical incisal control is raised to contact with the point of the incisal pin. When the condylar angulation for the lateral path of movement is different from the protrusive angulation, the condylar adjustment is set to the lateral path readings before the wing of the lateral vertical incisal control plate for that side is set. This adjustment is made by moving the upper cast laterally until the cuspids are in functional contact when the wing of the vertical control plate for that side is moved to contact with the point of the incisal pin and locked. The locks are then placed on the condyle rods; which makes the articulator a plane line instrument and the posterior teeth are set up as in a plane line with the anteroposterior and lateral curves in mind, the combination of which makes the compensating curves of occlusion as found in fine natural specimens with balanced occlusion. (Fig. 33.[1])

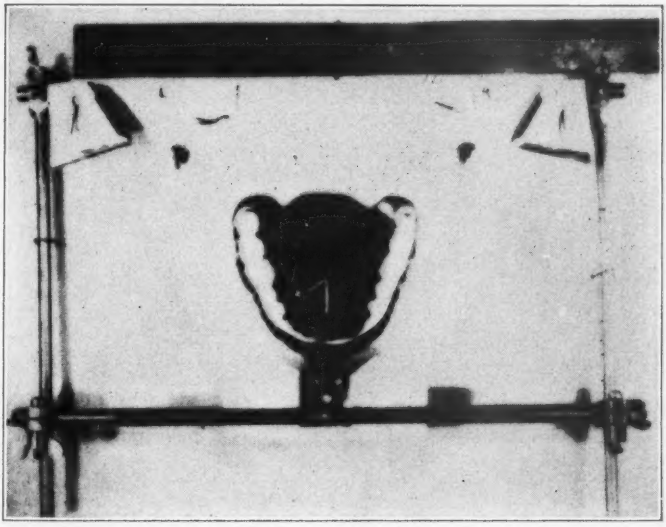

Fig. 28.—Maxillary appliance with targets attached. A casting of hard bronze was made to fit the vault and teeth. The occlusal surfaces of the teeth were exposed and tracings of the mandibular movements were made with the teeth in contact and also freed from contact.

When all of the teeth are in place, the condyle rod lock is released and the teeth

are tested and the balance corrected in both the lateral and the protrusive ranges in harmony with the readings registered for each. The case is then tried in and approved. When this is done, the incisal pin is lowered sufficiently to separate the posterior teeth about 1 mm. in the first molar region. The lower molars and bicuspids are then raised to the correct occlusion at this height, for the purpose of grinding and freeing the occlusion of the posterior teeth, without closing beyond the established centric relation and to prevent the excessive grinding of the anterior teeth.

The use of the facebow is not essential in using a hinge axis fully adjustable articulator, provided the established intermaxillary opening is not changed on the instrument, because all of the adjustments are relative. The correct use of the facebow permits of a more accurate transfer of the casts to the articulator. The ideal type of facebow is one which is independently adjustable on the two sides. It is of no special value, unless it is attached to the mandibular baseplate and each side adjusted separately to the axis of the opening.

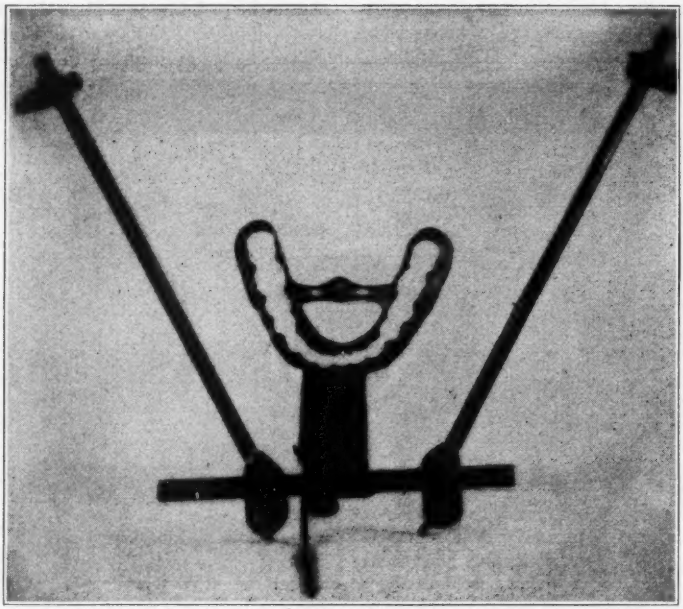

Fig. 29.—Mandibular appliance with tracing needles attached. The side bars are unilateral in adjustment. The gothic arch tracing on the maxillary plate may be noted.

The opening axis is correctly located if the point of the condyle bar of the facebow rotates at a fixed point on the face when the jaw is opened and closed from one-fourth to one-half inch. The Wadsworth "T" is used in conjunction with the facebow for locating the orbital plane which is parallel to the plane of occlusion. With its correct use when the

case is transferred to the articulator, the readings of the condylar angulations are then comparable with the anatomic condylar angulations of movement. This will permit of changing the vertical dimension between the casts on the articulator without causing discrepancies in the occlusion of the finished case.

Rigid baseplates are necessary for making accurate registrations, and vulcanite bases made over casts from muscle-trimmed impressions are the ideal, unless metal bases, such as gold, are to be used. These bases, after the registrations are taken, are luted to the articulator so they can be removed from the casts. Either single or double vulcanization can be carried through this way, or any base material may be used if desired, by removing the registration baseplate from the flask. When the case is vulcanized and finished, if not warped, it will fit the casts on the articulator accurately. This permits of a test for the accuracy of the finished dentures when placed on the casts on the articulator preparatory to grinding the occlusion. It also eliminates the inaccuracy of the checkbite for remounting the dentures for grinding the occlusion.

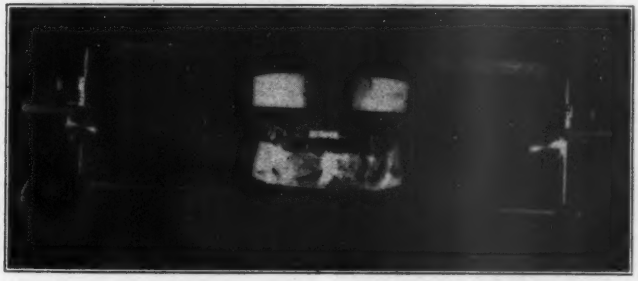

Fig. 30.—Gysi facebow attached to base with mandibular cast in conjunction with pointed bar attached to upper cast. This apparatus was used for measuring the degrees and angulations of condyle movements in various mandibular positions as recorded with checkbites.

TEETH

Much confusion is present in the minds of the profession regarding posterior teeth as regards bite depth, cusp angulation, etc. First, let use consider cusp angulation of artificial teeth. In order to understand this subject, it is necessary to consider the biologic and anatomic factors pertaining to natural dentition, which gives a basic foundation for study and application of mechanical designs as substitutes for Nature's handiwork.

It is known that in all of Nature's designs, no two things are exactly alike. This is true of the natural teeth as it is of other things in Nature. It seems impossible to find two teeth in opposite sides of the same mouth that are exactly alike. The cusps and forms of the teeth are different in individual mouths and are proportionately different in all cases, as is also cusp angulation, bite depth, arrangement in the arch, alinement, arch forms, etc. It seems to be Nature's ideal in her designs of teeth, osseous structures, etc., to bring about typal forms and combinations in cusp depth, overbite and esthetic values, that are pleasing and harmonious.

Efficiency in power and masticating function has not been overlooked; for, in no case recorded, has Nature eliminated in her designs the cusps of human teeth. It is true that Nature has designed different depths of cusps, different occlusal relations, and that growth and development varies in the osseous structure and muscular power. Attrition varies the occlusal forms of the teeth in all cases, on the basis of the type of the teeth and their relations and guidance in function, plus the age of the patient and the types of food used.

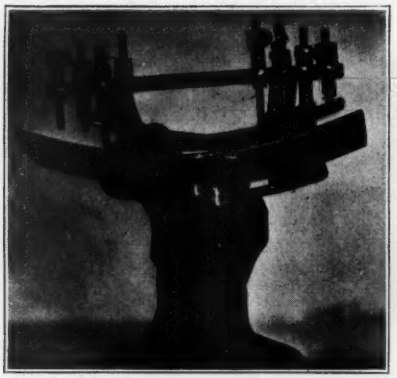

Fig. 31.—Another design of tracing and recording device with double gothic arch tracing needles and adjustable center stud support. This was used in comparative tests with other devices.

The size and form of the natural teeth are determined before eruption. Their contact in occlusion is the result of the natural forces of growth and eruption. Their alinement in the arch is due to the cusp angulation of guidance in function and their rotational positions are due to functional and cuspal guidance. Fine natural occlusion is the result of harmonious biologic, anatomic, physical and functional forces, plus environmental conditions.

Studies I have made of natural dentitions during the past twelve years reveal that the greater percentage of cases can be classified under two distinct types of balanced occlusion: (1) those cases with ideal development and function in which the teeth balance in all of the functional ranges of occlusion; (2) those cases of fine natural dentitions that balance in the masticating or lateral functional ranges of occlusion, but in which the posterior teeth do not contact in the protrusive or incisive occlusion. Where there is proportionate harmony in the occlusal wear

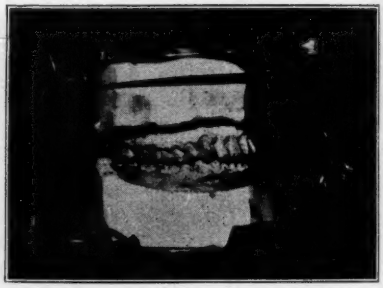

Fig. 32.—Split cast method for testing range and adaptability of articulator as designed by J. W. Needles.

of the teeth, both types seem to be ideal as regards function and oral health.

In young subjects of the same age, the first type shows much more rapid wearing away of the teeth, with usually less cusp depth and a much greater horizontal range of movement in function. The proportionate harmony of wear of this type is more nearly ideal and both the upper and lower anterior teeth show decided wear on the incisal edges. In the second type, the cusp depths are usually greater, and owing to the vertical guidance of the cuspids and cusp inclinations of the pos-

terior teeth, there is perceptible wear on the buccal cusps of the mandibular bicuspids and molars, with a corresponding wear on the lingual cusps of the maxillary bicuspids and molars. There is less wear on the incisal edges of the upper anterior teeth because of the overbite in these cases, but the lingual surfaces of the upper incisors and cuspid teeth show perceptible wear.

If the jaw development and the overbite of the anterior teeth in the natural dentitions have been conducive to fine esthetic harmony, both fixed and removable restorations give good results in the second type of balanced occlusion. This is exemplified by the retrusive type of mandibular development. Nature has, in such cases, developed form and function no two of which are alike. Therefore, we as a profession must study the anatomic development, function, esthetics and changes in each case, realizing that an arbitrary mechanical routine procedure is inimical to the highest degree of success. If full knowledge of all conditions present is obtained in each case, a correct mechanical application can be made. The degree of efficiency possible of attainment will vary in direct proportion to the conditions found in each case.

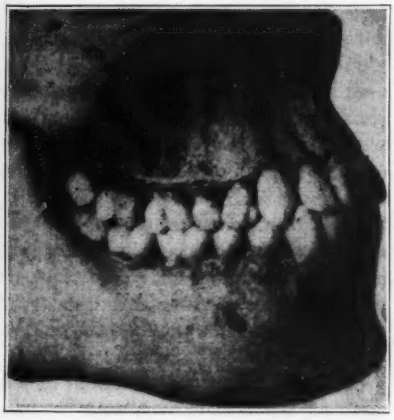

Fig. 33.—Skull with fine natural dentition and occlusion. A straight edge placed at the point of the cuspid and the point of the distobuccal cusp of the first molar is on a plane. The curve of the occlusion begins at the oblique ridge of the upper first molar. An embrasure may be noted between lower first and second molars.

The variations in the angulations of the movements of the mandible, typal and cusp forms, and arch alinements of the teeth, heavy and light osseous structures of the mandible and maxilla, etc., are important. They are neither new nor unknown to dental practitioners, but they are indifferently considered by the majority of them. It is simple to understand the importance of the foregoing conditions in anatomic development when one realizes that there are eight basic biologic combinations of the occlusal relations of the teeth. They cover all the conditions of leverage, stresses and esthetics that are encountered in restorative procedures.[9]

In the ideal development of both maxilla and mandible, there is a normal overbite of all the maxillary teeth in relation to the mandibular teeth. In the unilateral development of the mandible, there is a crossbite relation of the posterior teeth on one side. In the bilateral development, there is a crossbite relation of the posterior teeth on both sides of the jaw. As there is also an end-to-end relation of the posterior teeth, there are four basic occlusal relations of the posterior teeth.

There are also four basic relations of the anterior teeth: (1) the overbite of the upper over the lower teeth; (2) the end-to-end relation of the teeth; (3) the protrusive relation of the lower to the upper

9. House, M. M.: Physical and Anatomical Study of Occlusion, Dent. Cosmos, 70:913-920 (Sept.) 1928.

teeth; (4) the retrusive relation of the lower to the upper teeth. Various combinations of these conditions may be found present in one case, and they vary in degree only.

The various typal relations and combinations that are found in Nature predetermine the restorative requirements for artificial substitutes. Some variations from natural teeth are necessary in manufactured teeth. For instance, the buccolingual width of the posterior teeth must be reduced to allow for tongue space and to reduce the resistance to the masticating force for the relief of the residual tissues.

Cusp depths may be varied, as is shown in unworn specimens of natural teeth. Cusp angulations in artificial forms of teeth have been much overstressed and made a factor of confusion in the minds of the profession. Schematic drawings of cusp angulations harmonious with condylar inclinations as far as practical application is concerned, present hypothetical conditions. All specimens in natural dentitions show that the bicuspids have the deepest cusp forms, and that the cusp depths decrease posteriorly from the first bicuspid to the third molar. This shows again that, in Nature's design, the cusp depths of the teeth have been made harmonious with their ranges of movement in function. The opening movements of the mandible are comparable to a hinge, and the ratio of opening is proportionately greater in the anterior teeth than it is in the posterior teeth, as is also the lateral ranges of movement.

Many manufactured forms of teeth on the market have been made the reverse of anything shown in nature; i.e., the bicuspids have less cusp depth than the molars. The cusp forms, as well as the cusp angulations, as received from the manufacturers, have been carved according to the ideas of the different designers. The changing of the curves to effect a balanced occlusion different from the curve used in carving the master forms necessitates different vertical angulations of the teeth, which changes the cusp angulations proportionately. All baked porcelain teeth are slightly different in form from the master molds from which they are made. This is due to the change that takes place in making the mold, the wearing of the mold from use and the spherical change that takes place in shrinkage and glazing of the porcelain. These variations, plus the change in axial angulations in setting up the teeth, prevent the cusp angulations from being a factor of importance in artificial teeth.

Fine natural dentitions are found to be most harmonious and efficient in their occlusal relations after the first stage of wear. Evidence is conclusive that Nature corrects the inaccuracies of occlusion by harmonious wear of the teeth, according to their functional relations. It therefore seems that it would be a scientific procedure, in mechanical restorations, to make functional registrations of the mandibular movements and record them on a fully adjustable mechanism. Then, the grinding of the occlusal relations of the teeth on the articulator would be comparable to Nature's.

When the angulations and rotation centers in the lateral movements vary, it is impossible to rotate the posterior teeth in artificial restorations to coordinate or synchronize the cusp relations with the functional angulations of movement. Therefore, grinding them in the completed restoration is essential. By such a procedure, all interferences, cusp angulations, etc., are corrected and the occlusal relations of the teeth are synchronized with the functional forces and angulations of the mandibular movements of each case.

Nature has, in the natural dentition, provided sufficient material for this purpose, without creating excessive resistance to force in the efficiency of mastication.

From my studies and investigations I have made three changes in, or additions to, the sequence of steps in the technic that I have used and taught for the making of artificial dentures. In 1924, I proved the value of and incorporated the use of the rotary occlusal grinder as a routine procedure in the technic for freeing and synchronizing the occlusion of the teeth in harmony with the principles found in fine natural dentitions. In 1925, I made the use of vulcanized registration plates a routine procedure, unless metal base dentures were to be used. I also made functional registrations of all cases routine and eliminated wax checkbites for registering centric occlusions preparatory to grinding in the occlusion.

The foregoing has reduced irritation and the necessity for the refitting and rebasing of residual bearing appliances to the minimum, although I have used deep bite posterior molds of teeth in the majority of cases.

The angulations of mandibular movement, cusp form and opposing relations of the teeth show conclusively that it would be impossible for a patient ever to harmonize functional relations with arbitrarily set artificial teeth by chewing carborundum on either fixed or removable prostheses. It has been proved by actual tests that patients having angulations of movement for the protrusive range that are different from those of the lateral angulations, will chew a composite curve on occlusal rims made of carborundum and plaster. A composite curve of all these movements will not fit correctly in any range of occlusion. In my exhibit are two skulls with natural dentitions in which excessive occlusal wear has taken place, showing definitely the results of a composite curve.

CONCLUSION

There are four definite factors in the control of the angulations and directions of the movements of the mandible, namely, the muscles and ligaments, the condyle heads functioning in the glenoid fossae of the temporomandibular joint and the teeth. It requires a three dimensional method of registration to record the relational and functional position, angulation and direction of the movements of the mandible.

Any registrational method that fails to record all the directions, positions and relations of the mandible to the maxilla is incorrect and inefficient. An articulator, to be efficient, must be so designed that it will trace accurately the registrations found in each case. It is not only necessary that it shall trace the registrations accurately, but it also must be properly designed and fully adjustable so that the angulations and positions recorded can be accurately reproduced and definitely controlled.

A hinge axis articulator that is fully adjustable and three dimensional not only adds to convenience in use, but also simplifies the problem of adjustability to accommodate the overbite and cusp heights for esthetics and mechanical requirements.

The technic of application must be accurate and fundamentally correct, without the introduction of arbitrary steps in the sequence. Methods of registration and technic, to be efficient, must be applicable to all forms of restorative prosthetic appliances. Prosthetic restorations in dentistry are primarily and fundamentally esthetic and anatomic appliances. Simple, accurate and efficient methods in their construction are essential. The men-

tal confusion in the minds of the profession regarding this problem is due to conflicting interpretations regarding the principles involved as compared with the theories that have been evolved by the various writers.

Nature has provided freedom in the occlusion of the natural teeth in the triturating and functional ranges of occlusion, and the application of this principle in perfecting the occlusal relations of the teeth in prosthetic restorations is essential to the most successful and efficient results in practice. This means that the removal of occlusal interference must be accomplished by correctly grinding and synchronizing the cuspal relations of the teeth with the functional angulations of the mandibular movements of each case.

A study of both prehistoric and modern skulls in museums shows that jaw relations, osseous forms, typal combinations of tooth forms and correlated effects of wear of the teeth have not varied in many past generations.

Biologic, pathologic and temperamental factors, age and the general systemic health of patients prevent the possibility of empiric or routine procedures if satisfactory results are to be attained in dental practice.

The integrity, knowledge, skill and ability of the operator are of equal importance with all other factors in success.

Thirty years of observation in dentistry has conclusively proved to me that much advancement and progress has been made, and it is hoped that the future years will be conducive to building the superstructure on the foundation that has been laid for the objective of dentistry—a humanitarian health service.

TOOTH CONFORMATION AND POSITION IN OPERATIVE DENTISTRY*

By E. H. BRUENING, D.D.S, Omaha, Nebr.

IT is often hard to see in its true form, that with which one is in close contact almost every day. A look from a slightly different perspective may be conducive to revived or increased interest in the subject. This is particularly true of tooth conformation.

Prompting this article is a desire to bring to mind the importance of building into operations correct tooth form, in order to maintain or restore important functions of the teeth, such as the process of mastication, and the protection of the tissues in which the teeth are embedded, together with a short study of tooth conformation.

The function of mastication is an important step in the preparation of food or fuel for the human body. It is essential in order to maintain that most valuable possession—bodily good health or well being.

The incising action of the anterior teeth, with the subsequent trituration or breaking up of food particles, along with

*Read before the Section on Operative Dentistry at the Midwinter Clinic of the Chicago Dental Society, Feb. 3, 1931.

the mixing of saliva and food substances, brings into action the diastatic enzyme in the saliva, which changes the starches to maltose, or malt sugar. This, in turn, becomes the dextrose, or starch and grape sugars, which is so essential to all parts of the body.

The impairment of this function is prone to produce symptoms of malnutrition, the early evidences of which are commonly found in the mouth. Acidosis, or an excess of acid in the blood or in the urine, is one of the common conditions of unbalance, which so often causes congestion of the mouth tissues, or may lead to dental caries.

The protective action of proper tooth conformation must be recognized, because, without it, there would be a destruction of the supporting tissues caused by food impaction or irritation of the gingiva, which produces a syndrome of symptoms with which all are familiar. The fibers of the peridental membrane are destroyed, the bone tissue resorbs, and the glandular orifices are mutilated, with a resultant avenue of direct infection. This is a break in the outer or protective integument of the body, which may be as vulnerable as a break in the skin.

A study of the conformation of each group or class of teeth will readily demonstrate the protecting contours of the labial, buccal, mesial, distal, lingual and occlusal surfaces. Note, for example, how all of the lingual surfaces are formed to guide the bolus of food toward the tongue and away from the gingival tissues.

INCISORS

The first consideration in most cases is the labial surfaces of the incisors. Subconsciously, one decides whether they are in harmony with the facial outline and surrounding tissues, as to form, position and color. If they are, there is immediately aroused a desire on the part of the operator to do all in his power to keep them so. In case of decay, he wants to maintain or restore every line as Nature intended it to be, with the material best suited for the case.

J. Leon Williams has shown that there are three distinct forms of central incisors and has described them by classes. In Class 1, the proximal sides are parallel for one half or more of the length of the crown. This is called the square type. In Class 2, the proximal surfaces converge from the incisal edge to the gingival line. This is called the tapering type. In Class 3, the proximal surfaces present a double curve. This, which is usually found on the distal surface, but may be on either surface or on both surfaces, is the ovoid type. These three types are found in the skulls of all races, and are even more strongly marked in their leading characteristics in the gorilla, the orang-outang and the chimpanzee, a fact which strengthens the evolution theory. There are no racial types of central incisors.

The maxillary lateral incisors may be regarded as bridging the change in form from the central incisors to the cuspid. It is the distal surface of the central incisor that best expresses the character and beauty of the teeth. This expression in the lateral incisors is found on the mesial surface. The curvature of this surface is strikingly in harmony with the curvature of the distal surface of the central incisors. These lines impress one with a sense of underlying harmony struggling for expression.

The discovery of practically identical forms in faces and teeth led at once to the query as to whether Nature placed square teeth in square faces, tapering teeth in tapering faces and ovoid teeth

in ovoid faces. In a large percentage of cases, the face and teeth are of the same type, but often, with some modifications, and in a smaller number of cases, the face and teeth are of unlike type. The appearance is most pleasing when the outline forms of the face and central incisors are similar.

CUSPIDS

The upper cuspid teeth extend well forward to hold the lip in a position that gives strength and character to facial expression. They protect the weaker bicuspids from undue shock by accepting heavy loads when incising highly resistant foods. The curve of the lingual ridge and cingulum protects the gingival tissues by directing the incised substances toward the tongue, which, in turn, places it between the occlusal surfaces of the bicuspids and molars.

Their conformation and position make them very important in holding the teeth on each side in proper contact. When contact points are lost by caries or wear in the incisors or the bicuspids, there is an immediate reduction of interproximal space by pressure exerted by the cuspid tooth. The importance of understanding and restoring the correct proximal surface forms with an enduring, carefully placed filling material, cannot be overestimated. If a differentiation can be made as to which tooth should receive the most careful attention, let it be the cuspid.

Gold foil is the best material for all surfaces, if caries is not too extensive. In this case, a gold casting or jacket crown would be indicated; the operator endeavoring, in every instance, to restore the normal form for the case in hand. Silicate cements should rarely be used on the proximal surfaces of cuspids. When this material is used in the incisors, it should be frequently replaced and each time the teeth should be separated to allow space to restore correct tooth form. Building a too prominent mesial contact point on a cuspid can seriously interfere with an otherwise harmonious dental arrangement. It is better to separate the cuspid and bicuspid and make a necessary plus contact on the distal surface, as this surface is always more convex than the mesial, and much less conspicuous.

BICUSPIDS

The upper bicuspids are frequently the victims of proximal decay, and nowhere in the mouth is there a better opportunity to make beautiful restorations conforming to Nature's plan as to function and form. Examination of the occlusal surfaces reveals five developmental grooves: a mesial and distal triangular, a central, a mesial and a distal. These mark the outlines of the four lobes from which the enamel cap is developed. There are clearly defined mesial and distal marginal ridges with a depression where the mesial and distal grooves pass over these ridges lingually from the central line, forming what James M. Prime calls spillways or little ears. The contact point on the mesial surface is located in the buccal and occlusal third of the mesial surfaces. The contact on the more convex distal surface is a little nearer the center of this surface.

The wide embrasures are caused by this condition and the smaller mesiodistal diameter of the lingual half of these teeth. The lingual cusps are smoothly rounded. There are four ridges which lead away from the point of the buccal cusps; the buccal triangular ridge ends at the central grove, the buccal ends in the middle third of that surface. The buccal marginal ridges are very efficient cutting edges; the arms or mesiodistal inclines are about equal in length. The mesial and distal pits are definite and should always

be carefully reproduced. On account of the difficulty encountered in polishing sharp pits and grooves, it is well to leave them slightly rounded in their depths.

The gold inlay, after being carefully adjusted as to bite, should be refinished before setting, reproducing the pits, grooves and ridges, as indicated for the case. Gold foil, amalgam and other filling material should be carefully carved to correct tooth form for the case in hand. Sufficient separation is essential in all cases in order to reproduce the protective curvatures of the mesial and distal surfaces.

The lower first bicuspids sometimes present a rather difficult problem when it is necessary to reproduce the approximal surfaces, on account of the lingual inclinations of these teeth and the short lingual surfaces. It is usually necessary to involve all of the grooves on the occlusal surface to obtain sufficient anchorage for the filling material. This makes it necessary to reproduce them by carvings. If the same tooth on the opposite side is intact, it will serve as a pattern. This is of even more importance in the reproduction of the lower second bicuspids. There are three general forms, described by Stillson as the Y, U and H forms.

The Y form is the three-cusp type. The usual lingual cusp is divided by a lingual groove. The mesial and distal grooves are usually indistinct.

The U form is the one in which the central groove joins the triangulars in such a way as to form a half circle.

The H form has a straight central groove with a deep pit at each end. The triangulars and the mesial and distal grooves run almost at right angles to the central.

The lingual cusps of second bicuspids are often wider than the buccal cusps. The buccal surfaces of the bicuspids and molars have a distinctly characteristic lingual inclination, with a decided rounding or convexity extending from the gingival line to the point of the cusp. This is frequently overlooked in restorations that supply one or more of these teeth; which interferes with function and causes an unbalanced appearance.

MOLARS

There are three types of molars to be given careful consideration as to form: the uppers, the lower first and the lower second. The upper molars are similar except for difference in size, and the smaller distolingual cusps of the second and third molars.

The lingual surface is convex, which brings the linguoclusal margin well onto the occlusal surface. The buccal surface has much less convexity. This arrangement of cusps admirably fits into the scheme of occlusion, the lingual cusps occluding into the sulcus of the lower molars, the buccal cusp fitting over the convex buccoclusal margin of the lower molars.

There are four grooves and three fossae to be considered. The buccal groove extends from the central fossa over the oblique ridge, which is formed by the union of the triangular ridges of the mesiolingual and distobuccal cusps. An easy way to recall the location of this ridge is to remember that some examples of third molars have only three cusps. The distolingual cusp is the missing one. Consequently, its triangular ridge cannot be a part of the oblique ridge. The mesial groove extends from the central fossa over the mesial marginal ridge, forming a small secondary or mesial fossa, which is triangular. This groove divides, one part extending lingually and the other buccally from the mesial pit. The distolingual groove extends from the distal

marginal ridge (which it may cross), into the distal fossa, then over the lingual margin, onto the lingual surface. The depression posterior to the oblique ridge is the distal fossa.

The mesial and distal marginal ridges are close on their surfaces, and serve an important function in mastication. They are definitely notched and sharp enough to supplement the action of the cusps in grinding or macerating food. They also help to hold the food substance in place while mastication is in process.

The cusps are about one-fourth the height of the crown, and should be carefully reproduced in all restorations. This will reduce the muscular power required to prepare food for deglutition.

The fifth cusp is found on about 50 per cent of the first upper molars, and rarely on others. The restoration of this cusp is unnecessary, except for esthetic reasons.

The distal surface offers some difficulties in restoration, due to a concavity near the gingival line, and requires particular care not to leave an overhanging gingival margin in this area.

The buccal cusps of the lower first molar have been named by Dr. Diamond the mesiobuccal, the centrobuccal and the distobuccal. Dr. Black named them the mesiobuccal, distobuccal and distal. The changes suggested in dental terminology should receive the attention of the A.D.A. Committee on Nomenclature, and from that group will come some quite necessary simplification of terms.

There are five grooves to be considered on this tooth, one large fossa and three smaller ones. The mesial groove runs from the central pit across the mesial marginal ridge; the division of this groove forms the mesial triangular fossa. The buccal groove runs in a deep sulcus from the central pit across the buccal marginal ridge. The lingual groove runs from the central pit across the lingual margin. It is deeply sulcate. The distal groove runs distally from the central pit across the distal marginal ridge onto the distal surface, dividing the distolingual from the distal lobe. The distobuccal groove rises from the distal pit and runs distobucally over the buccal marginal ridge near the distal angle. It separates the distobuccal from the distal cusp.

The mesial and distal grooves divide the occlusal surface into the buccal and lingual halves. Because the triangular ridge of the distobuccal cusp is longer, there is a V-shaped deflection in this line.

The second lower or mandibular molars have four cusps. Very rarely, a fifth lobe appears on these teeth. The four developmental grooves do not often meet in the form of a true cross. The buccal and lingual grooves may be either mesially or distally from the central pit. Supplemental fossae are found in the mesial and distal areas.

The third molars will not be discussed in this short paper as there are so many variations in form. Each case must be studied as an individual one when restorations are necessary.

Outstanding among those who have recently contributed valuable thought to the subject of dental anatomy, I wish to commend M. Diamond, of Columbia University; William C. Stillson, of Western Reserve University, and James Mark Prime, of Omaha.

BASIC PRINCIPLES CONTROLLING THE SELECTION AND ADAPTABILITY OF ANESTHETIC AGENTS IN ORAL OPERATIONS*

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BOTH medical and dental history present ample evidence that, from the beginning of civilization, both empiric and scientific efforts have been made to combat pain and shock both physical and psychic during surgical procedures. While, in the early days, some measure of success was attained, it is only in comparatively recent times that a phase of practice has developed whose sole aim is to free humanity from suffering during operations and to carry it safely through its travail with a known and scientific measurement of metabolic changes occurring during and after surgical interference.

Because of our hectic modern life and the nerve fraying régime of the average citizen, combined with the known fact that operations can be performed painlessly, the laity of our day are demanding of us, on whom their health and safety often depend, that we add not one iota to their mental strain or their physical woes. They are assured by their general knowledge that dental operations can be performed without physical discomfort. That their beliefs are justified and that dentistry must live up to that challenge becomes a self-evident fact. Elimination of pain has become a necessity in modern dentistry. I feel that fear of pain on the part of the public is one of the important factors in the fact that a relatively small amount of dentistry is practiced per capita of our population. The dentist who does not recognize this fact is not only remiss in his duty, but, by his negligence, also is retarding progression of the profession as a whole.

I shall point out some of the salient data tending toward better standardization in the selection and adaptability of anesthetic agents in oral operations. I am not going to hold a brief for any particular agent, but shall try to outline the indications and contraindications for the use of the various accepted anesthetic agents. At the same time, I shall try to bring out evidence that the profession as a whole is overlooking the beneficent advantages of nitrous oxid and oxygen. Whatever agents are utilized, inadequate anesthetic results may be traced to a lack of knowledge of fundamental principles controlling their use, insufficient training in technic or a poorly developed psychology, for the range of our anesthetics is sufficient to meet all conditions and all phases of operating procedure.

Anesthetic training is possibly looked on by school authorities as a postgraduate study. In my experience, the average dental student, on graduation, is meagerly equipped in theory and practice to start his life work. Unfortunately, the practitioner who has been away from his school

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environment for even a few years is more or less out of touch with the progress of the times and can easily become careless or rusty in technic. Our postgraduate facilities in this field are limited today. Feldman,[1] in a recent article, says:

> Just as the field of graduate instruction is widening with universities in academic subjects, equally so must the dental schools take the lead in bringing back to their lecture and clinic rooms the many who feel that they wish enlightenment upon special phases of dental practice. I believe that this state of affairs will eventually come to pass. Closer cooperation between the dental societies and the dental school is the logical step forward in the scheme of dental education. Until this comes about my solution of the problem is that the dentist perfect himself in the technique of the administration of general anesthetic cases by associating himself for a time with one who can teach the clinical facts to him. The preceptor stage of dental education must again prevail.

We might enumerate the following as the more frequent operations indicating anesthesia: the preparation of sensitive cavities or abutments; the scaling of teeth in gingival or subgingival areas; pulp extirpation; apicoectomy; extraction; curettement; the curettement or removal of deep-seated pockets in periodontoclasia; operations on cysts; preparation of the mouth for dentures; reduction of fractures or dislocations; lancing of abscesses, and removal of benign epulides.

This list automatically rules out antral operations, cleft palate operations and operations on neoplasms, as they hardly fall in the field of general dentistry. We feel that antral operations primarily belong to the rhinologist, unless of strictly dental origin; in which instance, they are usually either handled by the specialist in oral surgery or by him in conjunction with the rhinologist. Clefts are distinctly not operations for general dentists, and malignant neoplasms are decidedly beyond the scope of our dental degrees. The other operations enumerated are dental in character or in the realm of oral surgery.

I assume that the majority of my readers are general practitioners of dentistry and that the above-named oral operations are more or less a routine with you. It is then to general dentists that these remarks are addressed.

The following anesthetic agents of recognized merit are at our disposal: ethyl chlorid and its combinations; ethylene; ether; procain; nitrous oxid and oxygen. Chloroform need not be mentioned, of course, as greatly superior and much safer agents are at our disposal. Formerly, its use was common, but it has long since been thrown into the discard because of its dangers and toxicity.

ETHYL CHLORID

Ethyl chlorid used locally as a spray has a limited field of usefulness for incisions, exceedingly brief surface operations or even simple uncomplicated extractions. Some operators advocate it especially for children whose temperament rather contraindicates an injection or when a narcosis seems unnecessary. Its topical anesthetic effect is so evanescent that it cannot be considered for operations of any magnitude or duration. In conjunction with methyl chlorid and ethyl bromid, ethyl chlorid has been used many years by hundreds of general dentists for short operations as an inhalation anesthetic. These agents individually have powerful toxic possibilities and must be classified as dangerous. In combination, they form a pleasing anesthetic from the patient's point of view. Exceedingly few reports of unfortunate sequelae have ever

1. Feldman, M. H.: Teaching General Anesthesia to the Dentist, Oral Hyg., 20:2413 (Nov.) 1930.

been reported, and I doubt that, in the years gone by, any agent has been utilized so promiscuously by the profession at large, numbers of whom have had little or no scientific training in anesthetic theory or practice. This combination is certainly indicated only in short operations and has absolutely no place in protracted procedures, and should dentolegal complications ensue, I feel that the operator would be far more secure had he used one of the agents more commonly recommended by both the dental and the medical profession.

ETHYLENE

Since its introduction, ethylene has found its sponsors and its opponents. My findings from a study of recent periodicals are to the effect that its proponents admit gas and oxygen to be the standard office anesthetic for general narcosis, but they employ with it oxygen or other synergists such as anesthol (chloroform, ether and ethyl chlorid) and oxygen, when, for some reason, they feel the need of a supplementary anesthetic agent. Some of its opponents characterize it as the "lamp post to the drunken pedestrian" and to the "cane upon which the unsteady walker may rely." I have utilized it in a short series of cases, and my conclusions are those of many anesthetists whose opinions must be held in great respect; namely, that while it is extremely satisfactory from the patient's point of view, and while the relaxation to be obtained is easily developed, it is absolutely unnecessary to the experienced gas-oxygen technician. It is more provocative of nausea than gas-oxygen. The postoperative period of analgesia is undesirable in office practice, and its explosive characteristics render it absolutely unsafe. Its field of usefulness is strictly in hospitalized cases and the general dentist had better let it alone.

ETHER

Ether has long held sway as a desirable agent in protracted operations, and it probably will occupy for a long time a definite niche in the field of dental anesthesia. Ether is not an office anesthetic. Careful preliminary examination and preparation is indicated. The patient cannot be moved safely for a long period. Its slow and diversified elimination renders hospitalization necessary. If the anesthetist is properly versed in the technic of gas-oxygen administration, there is in our field no operation, when performed in the office, that the latter agent cannot take care of as well without postoperative danger and possible complications. If ether is to be used, induction with nitrous oxid followed by ether with catheters is the preferable method, and an experienced anesthetist should be at the helm. The general dentist is remiss in his duty unless such cases are taken care of in conjunction with a medical practitioner. Eliminating the above-named agents, local anesthesia or nitrous oxid administration is left as most adaptable in dental practice. Of course, nonoxygenated nitrous oxid is not to be considered according to our present-day standards, for the operating time is too limited to be satisfactory, and the resultant so-called anesthesia is really an asphyxia and is attained by oxygen deprivation. This method so much used for many years became passé with the development of machines capable of carrying oxygen in combination. A comparison, then, of procain and gas and oxygen is in order. Each agent has its advantages and its disadvantages, its indications and its contraindications.

LOCAL ANESTHESIA

Since its introduction, local anesthesia has been very commonly used in general practice. A few years ago, procain brought about the elimination of cocain in our work, because of its comparative freedom from toxicity. The young dentist entering practice has had some training in its administration during his school years and its broad field of usefulness has made it seem peculiarly indicated in general dentistry. The armamentarium is simple and inexpensive. A few years ago, a bit of romance was thrown around the technic of its administration. Today, the technic is standardized, and most dentists understand it well and are reasonably adept in handling it. The economic features, that is, its low cost and the fact that trained assistance is unnecessary in its administration, its comparative safety and the rarity of serious complications, render it universally popular. Many patients wish to avoid general narcosis if possible. Phlegmatic individuals are unconcerned as to whether they are conscious while being operated on. Many patients associate the taking of any general anesthetic with some previous disagreeable ether administration and are willing to go to any limits to avoid again being made unconscious. In cases in which minor oral surgery is contemplated, the operator not versed in the administration of general anesthetics feels much safer. He also feels that the practically unlimited operating time at his disposal is an asset, particularly if he is not sure of his operating technic.

Forming a contrast with this side of the picture are types of patients for whom procain is certainly not the anesthetic of choice. He must indeed be an *n*th degree optimist who would maintain that the average child is a welcome asset to his practice if surgical work is necessary and local anesthesia is his bulwark of defense. All too often, children have been mentally upset by the well-intentioned, but misdirected, efforts of loving parents and solicitous friends. They have inadvertently overheard vivid descriptions of most of the painful and unhappy experiences which the family have undergone. Perchance, they have recently lost tonsils and adenoids under ether or, as often happens, a developing abscess has caused them loss of sleep. They are terrified. In my opinion, local anesthesia is not indicated in such cases. The original prick of the needle, no matter how skilfully performed, starts them off into fresh paroxysms of terror, and before the operation is completed, simple though it may be, the parents, the operator and the patient are total mental wrecks.

Going up the scale in age, we have other highly nervous patients of both sexes whose morale has been lowered by sleeplessness, suffering, dread or fear, and they do not face with equanimity the thought of operation while conscious. The utmost intelligent psychologic effort on the part of the operator often fails to allay excitement and fear and establish in their minds the difference between pressure and pain. It is hard to convince such patients that they are not uncomfortable. Everything that goes on in the operating room is under their vision. The sight of the instruments is liable to be terrifying. Criticism of technic, however unwarranted, is easily invited, and a comparison of your procedure with that of some previous operator is mentally made, even if not audibly expressed. Through nervousness and anxiety, the patient often reduces the dexterity of the operator in technic and prevents him from doing his best work. The argument regarding cooperation of the patient, so often advanced, has been admirably ex-

ploded by Woodward[2] of Pasadena, who says:

How many operators have we heard say that they prefer local anesthesia because they have the cooperation of their patient? That is about the best little alibi since Cain tried to laugh off the unfortunate little argument with his brother. About the only cooperation one ever gets from a patient is the negative kind, and even in the few cases where they try to help, their efforts through ignorance of the situation are such that they hinder rather than aid. If we need assistance we would much prefer the skilful aid of our office nurse.

For such overstimulated types, local anesthesia cannot be considered the anesthetic of choice. Gas-oxygen and a good technic offer far more surety of carrying the case through to a satisfactory conclusion. Premedication for these types is often indicated fully as much for local anesthesia as for a general narcosis. Sedatives, such as chlorotone, the bromids and the barbiturates, are often of great aid in ironing out the mental wrinkles and placing these patients in a more placid frame of mind. Thus, many obstreperous patients have been conquered and fear has been overcome, but, under gas-oxygen, better results can be obtained with far less mental stress for all concerned.

It is fundamental that local injections should not be carried into or through infected areas, and yet such injections are frequently made. Satisfactory anesthetic results are hard to obtain; localized breaking down of tissue is invited; sluggish areas develop, and there is often a real danger to the patient's life. Let me quote from a letter recently sent me by Timothy Leary,[3] medical examiner for the City of Boston:

In the past two years I have performed autopsies on two cases in which the extension of infection from the jaw to the sphenomaxillary fossa and following the fifth nerve to the gasserion ganglion and the meninges had occurred after novocain extraction of teeth. I have certified without autopsy two more. This in addition to several cases in which I have been called in and certified the death following wholesale extraction where the underlying cause was circulatory — either cardio-renal disease or arteriosclerotic heart disease.

Acute infectious processes, irritated third molar areas, cellulitis and allied lesions absolutely contraindicate local anesthesia. Where trismus is present, it is mechanically impossible to use it successfully. I feel that in most impacted third molar removals, in general, whether disease is present or not, procain is not the anesthetic of choice. He must indeed be a person without nerves who can withstand the customary procedure involved in the removal of a deeply impacted tooth without psychic shock. As pointed out by McKesson,[4] anoxemia is present in both general and local anesthesia. In mandibular injections, this anoxemia represents itself in a temporary partial suspension of circulation to the part. Consequently, the blood clot is slow in forming, and the operated area is more subject to contaminating outside influences. The profuse primary blood flow following surgical interference under gas-oxygen and the immediate blood clot formation are of utmost importance in preventing so-called dry socket and in healing the area. My experience is that fewer postoperative complications ensue in this region if gas-oxygen is utilized. The objection often offered is that such careful operating in inaccessible territory is not possible. This becomes a matter of operative dexterity and should not be used as

2. Woodward, C. M.: Nitrous Oxid as the Anesthetic of Choice, Pacific Dent. Gaz., 38: 223 (April) 1930.

3. Leary, Timothy: Personal communication to the author.

4. McKesson, E. I.: Essentials of Nitrous Oxid Anesthesia, J. A. D. A., 13:7 (April) 1926.

an argument. If the patient's interest, safety and comfort are jeopardized to cover up one's operative insufficiency, it is time that the operator improve his technic to such a degree that he can think of the patient first. If he cannot in employing gas-oxygen anesthesia develop a proper technic in the removal of impacted teeth without overtraumatization, he had better leave such cases to those who are able to do so. I feel that the patient's interest has not always been the first consideration. The mental strain and shock which a patient must undergo in any impacted third molar removal is more than negligible, and while local anesthesia can and probably does eliminate physical pain, a general narcosis minimizes both physical and psychic shock.

It is not my purpose to condemn local anesthesia. I am merely trying to point out that while its indications are many, it should not be promiscuously utilized. It has proved a most useful adjunct in my practice for many years, and I wish only to help you to judge as to when and when not to employ it. I trust that I am not prejudiced as to the value of either method of anesthesia. I use both, and could not maintain my practice happily without each of them. I am convinced that every dentist who includes oral surgery in any of its phases in his practice cannot limit himself to the one method to the exclusion of the other because no one method can satisfy all conditions. Candidly, I am desirous of stimulating a more scientific interest in the use of gas and oxygen, because I feel that it has been too much neglected by the general dentist.

NITROUS OXID AND OXYGEN

All things considered and all other things being equal, nitrous oxid-oxygen is without doubt the best office anesthetic at our hands. Unfortunately, all other things are seldom equal. If we can for a moment picture the dentist as well trained in general anesthesia; if he utilizes anesthesia to such an extent that the attendant expense for equipment and maintenance is not important; if his assistance at the chair is adequate; if he employs an experienced anesthetist, his anesthetic difficulties will be practically nil and his patients will be assured of an admirable service. All of these premises are seldom fulfilled in the average general practice.

TRAINING IN ANESTHESIA

Proportionately few general dentists are sufficiently versed in theory and practice to be able uniformly to deliver safe and satisfactory gas-oxygen anesthesia, taking all types of patients as they come; and if he is not sure of handling his anesthetic problem, the dentist is doomed to failure. You cannot learn gas-oxygen administration from a book. Clinical experience and plenty of it is the only background for successful results. The closets of many a dental office harbor discarded gas apparatus, junked for no other reason than that the prophecies of a glib-tongued salesman could not be fulfilled. Nothing wrong with the outfit, nothing wrong with the anesthetic agent, but the dentist all wrong in believing that he could deliver sane and safe anesthesia from theoretical knowledge alone.

The novice cannot look at the clock, set certain dials, turn on the gases and have his patient in all instances react as he expects him to. Although we have been taught that approximately 90 per cent of patients react normally, the law of averages is bound to slip in one of the 10 per cent once in a while. Then what becomes of our theory? The dentist becomes panicky, the untrained assistant loses her head, the patient is improperly anesthe-

tized and the operation is a failure. A perfectly functioning apparatus is then thrown into the discard and a beneficent anesthetic agent gets a bad name.

There is only one way in which satisfactory anesthesia can be obtained and that is through a knowledge of anesthetic signs and their signification, and no agent produces them so definitely as does gas-oxygen. They are like the guideposts on a well-marked highway. Admittedly the safest agent, gas-oxygen is the hardest to administer successfully. The border lines are extremely narrow; the difference between successful administration and absolute failure is governed by the operator's knowledge of normal signs and danger signals and his ability to utilize that knowledge. I believe that gas and oxygen should be used more and more, but the dentist without ample clinical experience should no more attempt operating on theory alone than a would-be aviator should undertake solo flights without adequate preparation.

ASSISTANCE

Adequate assistance is of paramount importance. One person cannot successfully administer gas and oxygen and operate in the mouth at the same time. While the dentist is legally responsible for the case, his anesthetist must be amply trained to take the anesthetic load from his mind. Accustomed to working together, they become able to fit one phase of the work into the other, and the operator finds that, in a short time, he is operating more delicately and traumatizing his cases less than ever before. The anesthetist must tend to her work and not allow her mind to be diverted by any interest in the operating end of the case. When she is well trained in the various eye, respiratory and other muscular signs of normal anesthesia and the equally significant warnings which are far more definite than with any other agent, patients become as safe as when in a fast express train with a trusted engineer at the throttle.

EQUIPMENT

Contrasted with the paraphernalia connected with local anesthesia, gas-oxygen equipment is expensive and its installation is hardly justified unless the dentist is using it to quite a degree. The modern machines are marvelous pieces of mechanism, and with their increased possibilities for successful results, they are the only types which should be used. There are very few of the 1915 models left in the automotive industry. The apparatus should be frequently gone over and kept in perfect mechanical condition and the rubber parts, which deteriorate, even if not used, should be renewed as the occasion demands.

INDICATIONS FOR GAS-OXYGEN ANESTHESIA

I know of no physical contraindications to the use of gas and oxygen. When it is properly administered, the blood pressure is scarcely raised, although it is never lowered. High blood pressure is not a contraindication if cyanosis, which warns of approaching asphyxia, is not allowed to develop. In pregnancy, it is the anesthetic of choice. As indicated before, it is ideal for children, and it may be used for patients of all ages. We consider it ideal for the weak and debilitated, for the anemic and the diabetic. To quote Beckwith[5]:

> The longer the operation and the more exacting the surgical technic, the more need for nitrous oxid-oxygen, for the action of the anesthetic is definitely known and there is no other anesthetic either general or local that so well protects the brain cells from shock

5. Beckwith, J. H.: Nitrous Oxid-Oxygen and Suggestions Relating to Its Administration for Removing Teeth, Cur. Res. Anes. Anal., 9:127 (May-June) 1930.

and at the same time produces no tissue or clinical change in any organ or tissue cell.

CYANOSIS

We occasionally have a physician question us as to the proper anesthetic for his patients, and he frequently objects to the use of gas because of the possibility of cyanosis. We usually find that this medical man is living in the dark ages of anesthesia and thinking in terms of straight gas asphyxia. With oxygen in proper combination, with a perfectly delivering modern machine feeding the gas with controlled pressure and definite percentages, cyanosis is rarely seen. The ideal operating period is in the middle of the third stage, and there it is not approached. Cyanosis *per se* is not a danger signal. Plethoric types with thick necks and mechanical respiratory obstruction sometimes become cyanosed without gas, and anemic patients may be in deep anesthesia and never become cyanosed. If the other signs are favorable, cyanosis means nothing. Fortunately, the warning signals of this condition are so evident that ample time is at our disposal to obviate its development. If, inadvertently, cyanosis does develop, a quick analysis of its causation must be arrived at and proper means taken immediately to dispel it. In conjunction with our anesthetizing agent, we fortunately have at our immediate hand oxygen, the great resusitating agent. Carbon dioxid also may be utilized by being run through the same machine. Many operators today consider that this agent is indispensable. I consider it an unnecessary adjunct if the gas-oxygen administration is conducted along rational lines.

The dentist must, in many instances, develop an operating technic quite different from that under local anesthesia. While time is not usually a factor, many operators feel impelled to hurry. Speed is unnecessary, but the time element can always be cut if a dextrous operating ability is developed and a well-trained team accustomed to working together will always bring better results.

ELEMENTS FOR SUCCESS

Successful results under gas-oxygen anesthesia will depend on many small things. The patient's stomach should preferably be empty, although a long fast is not indicated. Some years ago, Wohl and Harms[6] advocated the judicious use of orange juice as a preventive of acidosis. We have followed this preliminary detail as a routine procedure for a long time and have found it beneficial. A sedative the night before the operation allays fears and assures a better night's sleep for the apprehensive patient. This need not necessarily be an opiate. We have many analgesic and hypnotic agents which are useful. Some operators advise premedication an hour or so before the operating time. We find it is rarely needed, although in overstimulated types, it is useful. These types include children, highly nervous patients, alcoholics, narcotic addicts and those engaged in hazardous occupations. Of the last, examples would be policemen, aviators, locomotive engineers, structural steel workers and I might add racketeers and gangsters.

For such, a heavy preoperative medication is frequently essential. They are apt to be troublesome during the second stage of anesthesia, both going under and coming out. The experienced anesthetist can carry them over this stage quite easily as a rule. While patients are unconscious under our hands, we are responsible for their welfare, and as an added safeguard, we favor the use of restraining straps,

6. Wohl, M. G., and Harms, B. H., quoted in editorial: Orange Juice and the Acidosis of Anesthesia, Cur. Res. Anes. Anal., 4:65 (April) 1925.

preferably adjusted just after the patient loses consciousness. They can be removed just prior to the return of consciousness, after the zone of possible trouble has been passed, and the patient can be kept unaware that he has been restrained.

I utilize straps in all cases because the trouble maker does not always give us warning, and, in addition, we find that they assist in keeping the patient in the proper position in the operating chair. They are particularly useful if the case has been carried to complete relaxation. A properly selected mouth prop is essential and should be placed in the mouth just prior to the induction of the anesthetic. The patient should be properly placed in the chair, with the head in such relation to the body that free and normal respiration will not be hindered. The inhaler should fit smoothly without undue pressure as the ingress of atmospheric oxygen can easily upset the mixture running through the machine. The throat pack is absolutely essential, for several reasons; namely, because it prevents the inspiration of blood and pus in surgical cases; it gives the operator an unobstructed field to work in by its absorption of blood and saliva; it prevents loose detached particles, such as root fragments, detached filling materials or elusive teeth, from being swallowed or possibly blocking the respiratory passages and, further, it prevents atmospheric oxgyen from entering, and thus a definite percentage of gas and oxygen can be maintained.

The psychologic factors are of great importance. Confidence in the operator on the part of the patient must be obtained, and this can be instilled only by the calm, assured attitude which naturally is injected by one who is himself confident as to what he wants to do and how to do it. Quiet during induction and on awakening greatly reduces overstimulation in these periods. We must bear in mind that all sounds are magnified under partial anesthesia. The patient should empty the bladder just prior to administration. This is especially important for children as complete relaxation is usual and micturition in the chair may occur with a child or an adult. Adequate recovery room facilities furnish mental and physical comfort, and dignified thoughtful cooperation and a sympathetic attitude on the part of all in the office play their part. Because of erotic suggestions which may develop in the subconscious mind of the anesthetized patient, we have ample precedent in stating that gas-oxygen anesthesia should never be instituted without the presence of a third party.

Many of these simple details may seem unnecessary, but, as before remarked, the adaptability of gas-oxygen anesthesia and its selection for oral operations depend on a careful regard for details such as these.

CONCLUSION

I wish to reiterate that with procain and with gas and oxygen, we have at our disposal anesthetic agents capable of taking care of the anesthetic needs of the dental profession today. The indications and contraindications of each are clear-cut. It behooves the well-rounded operator to be conversant with each method and to make a judicious selection based on his own ability, his experience and the patient's requirements. Of the two methods, present-day gas and oxygen offers a broader and more extended field of usefulness, and the status of our profession in the eyes of the world will be enhanced as general dentists recognize this fact and perfect themselves in the technic of its administration.

270 Commonwealth Avenue.

ETIOLOGY OF ENAMEL HYPOPLASIA IN RICKETS AS DETERMINED BY STUDIES ON RATS AND SWINE*

By HENRY KLEIN, D.D.S., Sc.D., Baltimore, Md.

WORKERS in the field of rickets are generally agreed that all newly formed bone matrix is uncalcified in rickets. This is also true of newly formed alveolar bone and dentin.

The changes in the enamel are not so clearly agreed on, and those changes which have been noted are still in dispute as regards their etiology. This is especially true of the specific etiology of enamel hypoplasia, so frequently observed in rachitic children and experimental animals.

Erdheim,[1] Mellanby,[2] Kronfeld,[3] Gottlieb[4] and Bauer[5] are all agreed that one of the predominant effects of the ingestion of rachitogenic diet is enamel hypoplasia of the developing tooth germs and erupted teeth which have been subjected to the effects of an unfavorable dietary during their development.

Gottlieb and Bauer have attempted an investigation of the specific etiology of such hypoplasia. Gottlieb has concluded from a study of his material that hypoplasia is caused by the breaking down of normally formed but poorly calcified enamel matrix. He states further that the degeneration of the ameloblasts is a secondary phenomenon, caused by the initial fault in the enamel matrix. The terms ameloblast and ganoblast as used in this paper have the same meaning, referring to columnar cells lining the periphery of the enamel. William Bauer, in a paper published later, attempted to determine whether hypoplasia was caused by faulty calcification of the matrix or by a primary disease of the ganoblasts. He found the ganoblasts and the ameloblastic layer separated and torn from their normal positions by edema. He concluded that hypoplasia is the result of loss of function of diseased ameloblastic cells.

Unfortunately, both Gottlieb and Bauer worked with material having obvious limitations. Each worker described the effects in a rachitic child from necropsy material.

It becomes of interest to determine which of the two views is correct. Accordingly, the following experimental work was planned and instituted.

*Research supported by grants from the American Dental Association and from the dental staff of the Johns Hopkins Hospital.

*From the Department of Chemical Hygiene, School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md.

*Read before the Section on Biologic Sciences and Research at the Midwinter Clinic of the Chicago Dental Society, Feb. 4, 1931.

1. Erdheim: Rachitis und Epithelkorpeschen, Dentschr. d. math. u. nat. Klasse d. kais. Akad. d. Wissenschaften, 90, 1914.

2. Mellanby, May: Brit. J. Dent. Sc., 64: 70 (March) 1921.

3. Kronfeld, Rudolf, and Barker, F. J.: J. Dent. Res., 10:379 (June) 1930 (abstr.).

4. Gottlieb, Bernhard: Wchnschr. Zahnheilk., 1920, No. 2.

5. Bauer, W.: Vierteljahrsschr. f. Zahnheilk., 45:62, No. 1, 1929.

EXPERIMENTAL DATA

A series of swine were fed a rickets-producing diet identical with that fed swine in a previous investigation.[6] They were killed at various intervals and the skulls fixed in neutral 10 per cent formalin (solution of formaldehyd). Sections were then made of the developing permanent incisor tooth germs. A series of parathyroidectomized rats were fed a rachitogenic diet and killed at varying intervals, and sections prepared and stained.

RESULTS

A study of the sections obtained from the experimental swine and rats permits certain definite statements concerning the specific etiology of enamel hypoplasia. These observations substantiate and extend those of Bauer. They indicate that the interpretations of Gottlieb are open to criticism.

The outstanding effect on the enamel of rats and swine produced by a rachitogenic diet is an extreme wavelike hypoplasia. (Figs. 1, 4 and 6.) The condition of the enamel and ameloblasts in control animals is illustrated in Figures 2, 3 and 5. When the sections are studied in greater detail, particularly those from rats, it is found that proliferation of the cells of the outer enamel epithelium has occurred in the rachitic animal.

In addition, a greater number of what would appear to be spaces in the outer enamel epithelium filled with a clear fluid are noted in the sections showing hypoplasia. The fluid within the clear spaces extends toward the ameloblastic layer. The proliferation of the cells of the outer epithelium is accompanied by what appears to be an excessive production of gellike substance elaborated by the cells of the outer enamel epithelium. This excessive fluid seems to flow toward the ameloblastic cells. (Fig. 9.) The fluid or substance whose origin is within the outer enamel epithelium penetrates between the individual ameloblasts. (Fig. 10.) At the same time, the edema-like process in the outer enamel epithelium causes pressure against the base of the ameloblasts. This pressure tends to displace the nuclei, which normally lie near the base of the cells, toward the upper part of the ameloblasts in the direction of the newly forming enamel.

The granular structure of the ameloblasts is at first little disturbed, but the migration of the nuclei is distinctly discernible. (Fig. 10). The granular substance of the ganoblasts then becomes rarefied and an infiltration of the edematous fluid occurs between the cell bodies of the ameloblasts. (Figs. 9-11.) The fluid accumulates between the ameloblasts to such an extent as to cause the nuclei of the adjacent ameloblasts to become displaced. The group of ameloblasts so affected finally undergo an edematous degeneration, only remains of the nuclei of the destroyed cells being evident. (Fig. 10.) As a result of this degenerative process, whose origin seems to be in the outer enamel epithelium, the function of the ameloblasts is disturbed, and finally the excessive pressure upon the ameloblasts results in loss of function, partial or complete, depending on the extent of the disruption of the ameloblasts by the edematous process. The nuclei of the ameloblasts become elongated because of pressure changes. They are normally spheroidal. In many of the specimens, they become elliptical or even stringlike in form. (Fig. 11.)

6. Klein, Henry: McCollum, E. V.; Buckley, S. S., and Howe, P. E.: Relation of Diet to Skeletal Development of Swine, Including Development of Teeth, J. A. D. A., 17:782 (May) 1930.

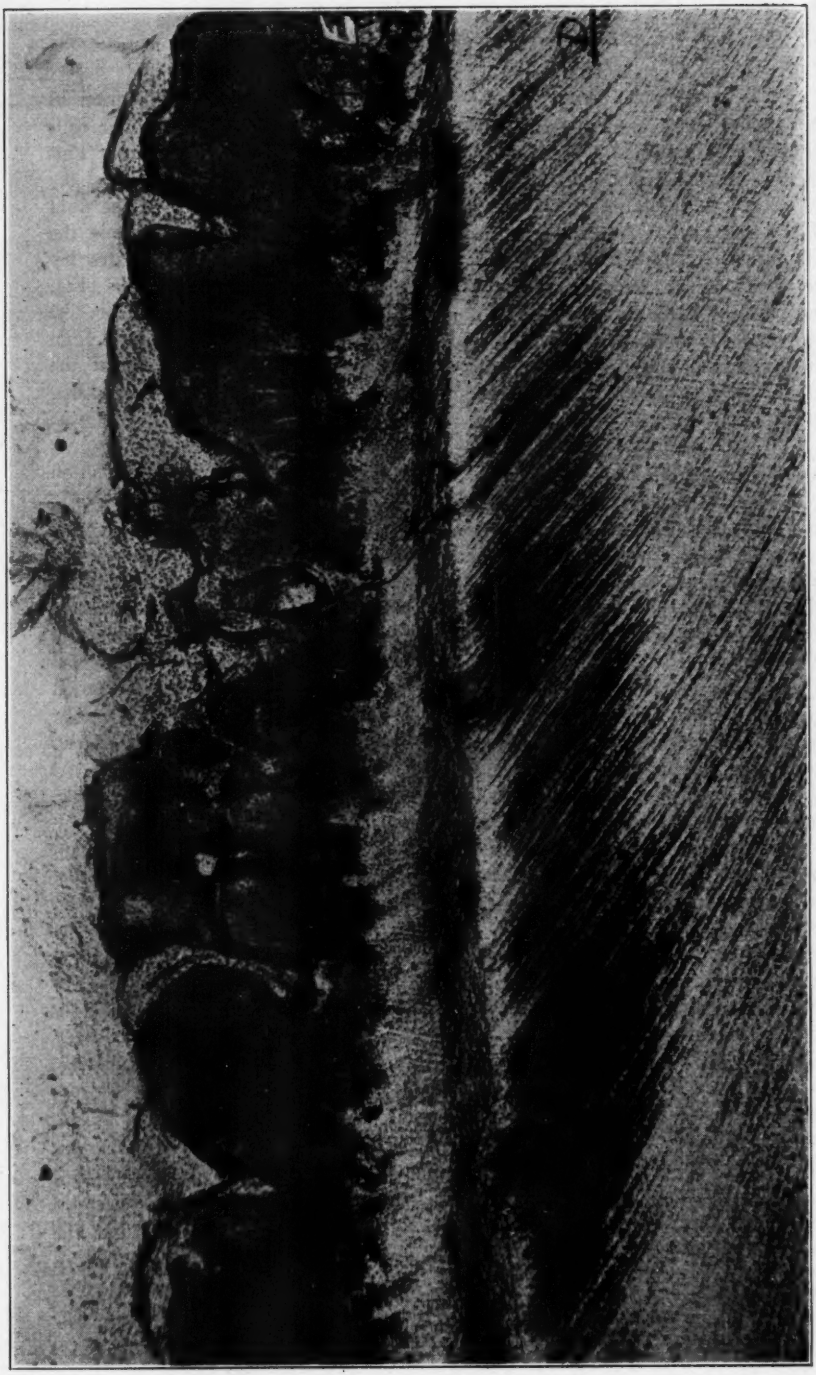

Fig. 1.—Effect of feeding a poor diet for one year, followed by a year on an adequate diet; ground section of newly erupted central incisor of a 2-year-old pig, from birth until 1 year of age on a low calcium, high phosphorus diet (rickets producing), followed the second year by corn and tankage diet. *E*, hypoplastic enamel; *D*, dentin. (×42.)

Fig. 1.—Effect of feeding a poor diet for one year, followed by a year on an adequate diet; ground section of newly erupted central incisor of a 2-year-old pig, from birth until 1 year of age on a low calcium, high phosphorus diet (rickets producing), followed the second year by corn and tankage diet. *E*, hypoplastic enamel; *D*, dentin. (×42.)

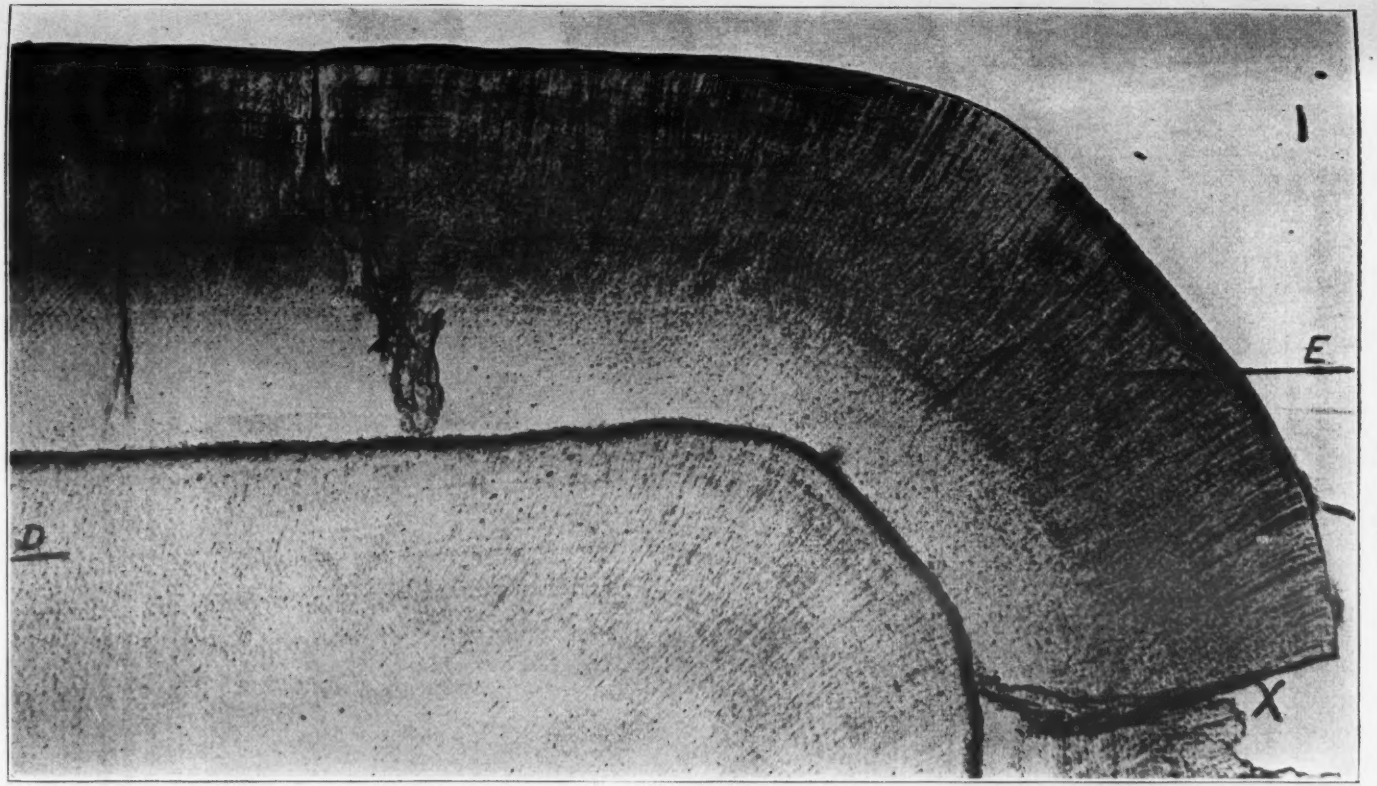

Fig. 2.—Effect on the erupted enamel of feeding an adequate diet for two years; ground section from 2-year-old pig on control diet from birth until 1 year of age, followed by corn and tankage the second year. *E*, enamel structure; *D*, dentin well calcified; *X*, cracks produced in grinding section.

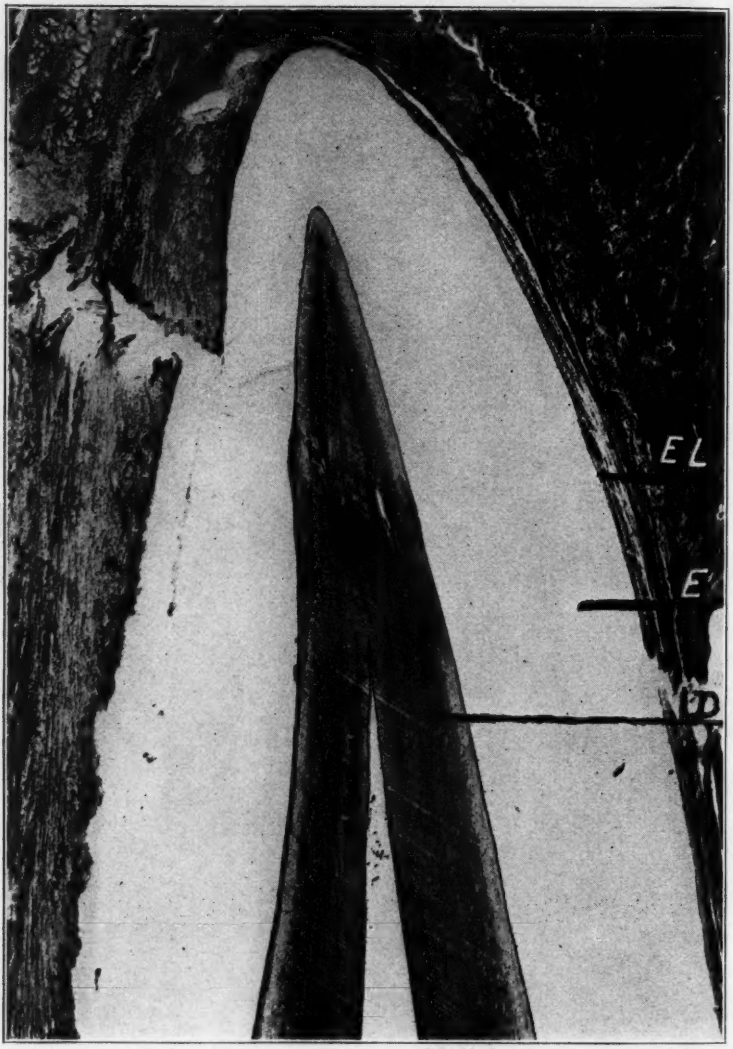

Fig. 3.—Effect of feeding an adequate diet to swine during development of permanent tooth germs; mandibular third or central incisor unerupted. *EL*, unbroken outline of ameloblastic layer without folds; *E*, enamel so well calcified as to be entirely removed during decalcification process in preparation of section; *D*, well calcified dentin (×16.5.)

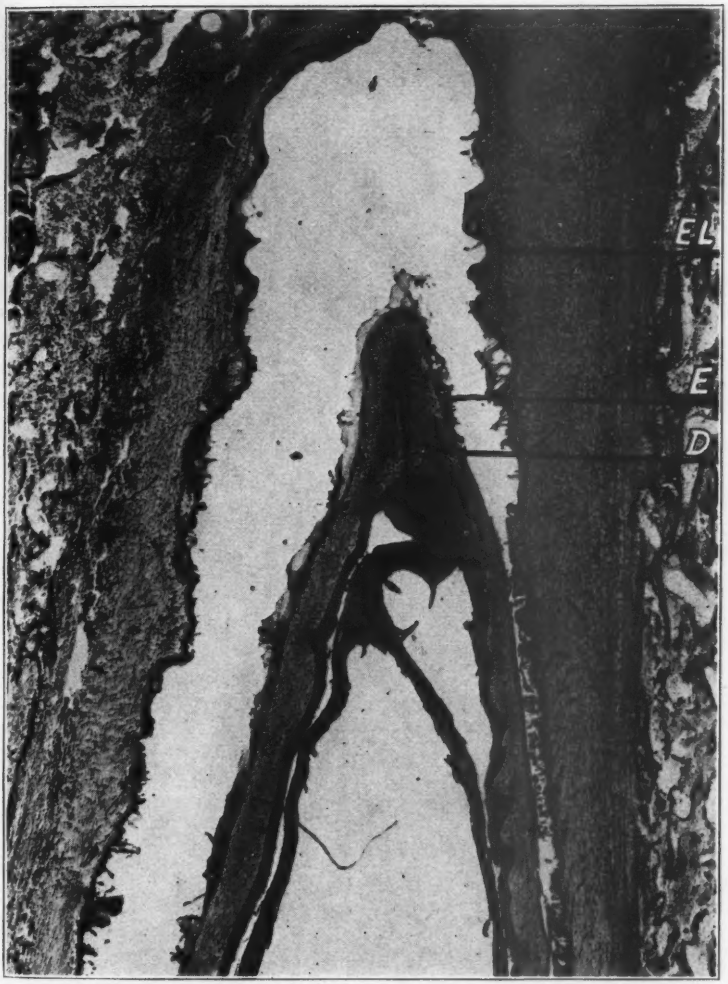

Fig. 4.—Effects of feeding a low calcium, high phosphorus diet to swine during development of permanent tooth germs; central incisor tooth germ. *EL*, folding of the ameloblastic layer; *E*, remains of organic portion of enamel; *D*, poorly calcified dentin. (×16.)

While the ameloblasts affected by the edematous pressure are becoming disabled, they gradually lose the ability to direct the deposition of enamel. The adjacent ameloblasts are also affected, but to varying degrees. The ameloblasts adjacent to the one or two most affected continue to perform their function in di-

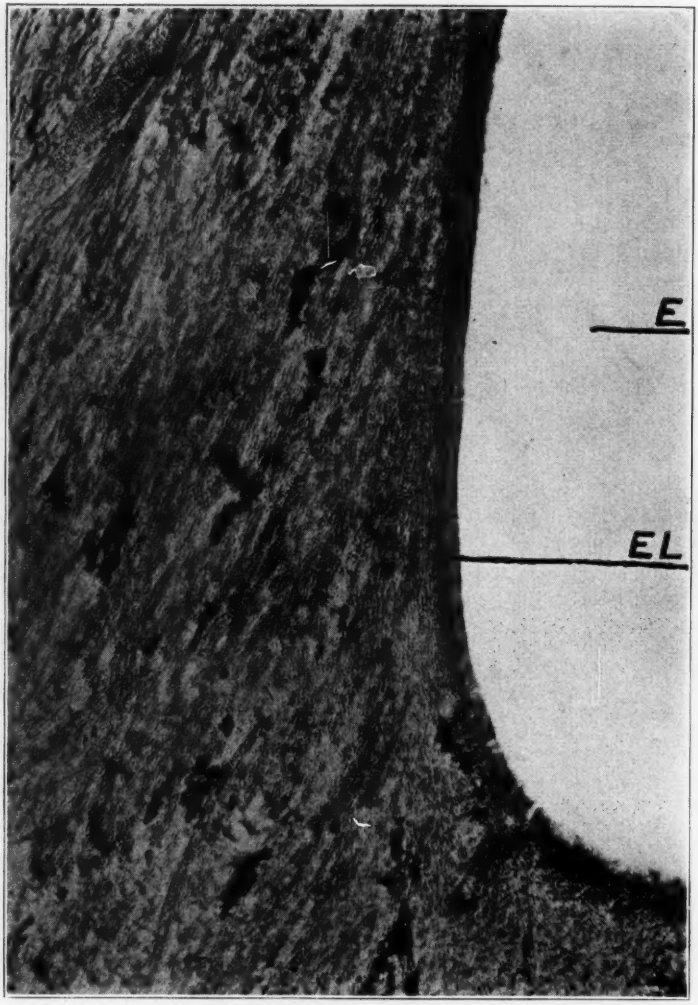

Fig. 5.—Effects on the structure of ameloblastic layer of feeding adequate diets to swine during development of permanent incisor tooth germs; section from pig on control diet for one year followed by corn and tankage the second year. *E*, enamel removed in preparation of section; *EL*, ameloblastic layer with no folding.

recting the deposition of enamel substance. As a result, enamel substance is deposited around the defective locality by less severely affected ameloblasts, and finally it is noted that the ganoblasts which have lost their function have disappeared through

pressure atrophy, and only the distorted remains of the nuclei may be seen. (Fig. 10.)

In other localities, the edematous process may begin within the ganoblastic layer immediately adjacent to the outer enamel epithelium. The edema is always noticed first between the individual ameloblasts. (Figs. 9-13.) The fluid in this locality accumulates and causes, first, a separation of the ameloblasts, and then a destruction of the body of the ameloblasts, accompanied by a distortion in shape of the nuclei. (Fig. 2.)

The suggestion of Gottlieb that the enamel ground substance is first affected and that the disturbances in the ameloblasts are secondary is open to criticism. A study of sections of rats and swine indicates that defects in the deposition of the enamel ground substance follow rather than precede the edematous degeneration in the outer epithelial layer and the ameloblastic cells. In certain sections where calcification of the enamel began before the diet was fed, beginning changes in the outer epithelial layer and between ameloblasts are noted in the absence of any changes in the enamel matrix. (Fig. 12.)

One of the most striking effects mentioned previously of feeding ricketogenic diets is the resulting proliferation of the cells of the outer enamel epithelium. These grow at such a rate and proliferate so rapidly as to be almost malignant in character. They invade and disrupt adjacent tissue. In a number of instances, the cells of the outer enamel epithelium have penetrated through the ganoblastic

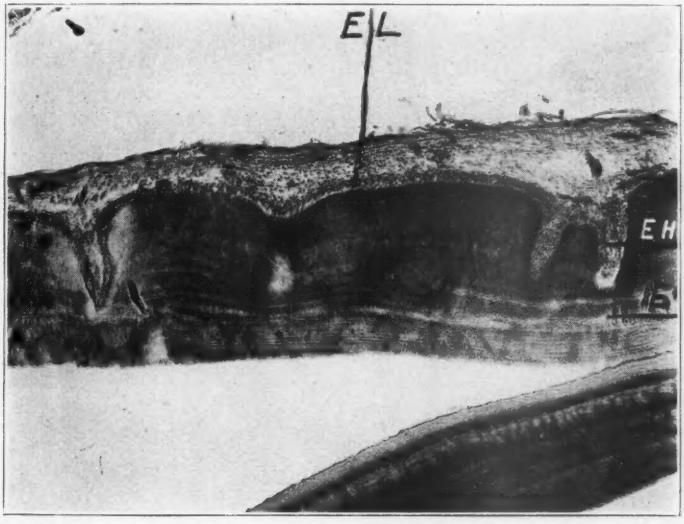

Fig. 6.—Effects on permanent central incisor tooth germs of a pig fed on low calcium, high phosphorus diet during development of tooth germs; section from pig on low calcium, high phosphorus diet from birth until slaughtered. *EL*, ameloblastic layer showing folds; *EH*, hypoplastic enamel; *E*, enamel; *D*, dentin.

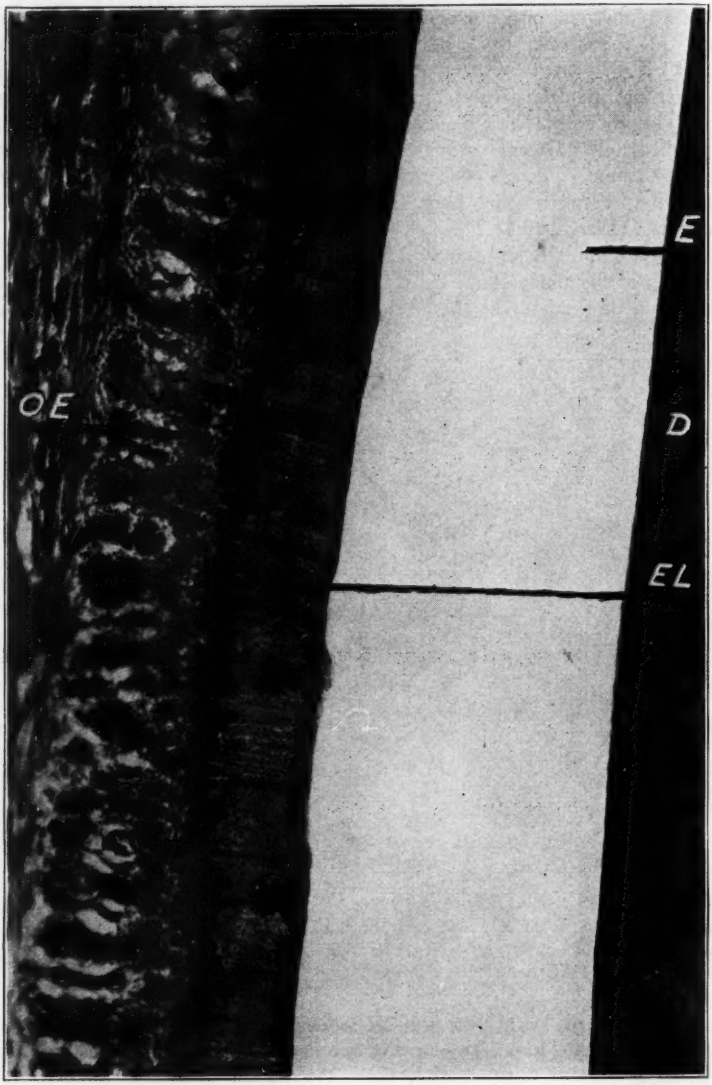

Fig. 7.—Effects on ameloblasts of developing incisor of rat fed adequate diets containing 9 per cent cod-liver oil. *E,* enamel removed in preparation of section; *D,* dentin; *EL,* undisturbed ameloblasts with nuclei lying at base of each cell; *OE,* outer enamel epithelium. (McCollum rat No. 193W XIX, age at death, 305 days.) (×420.)

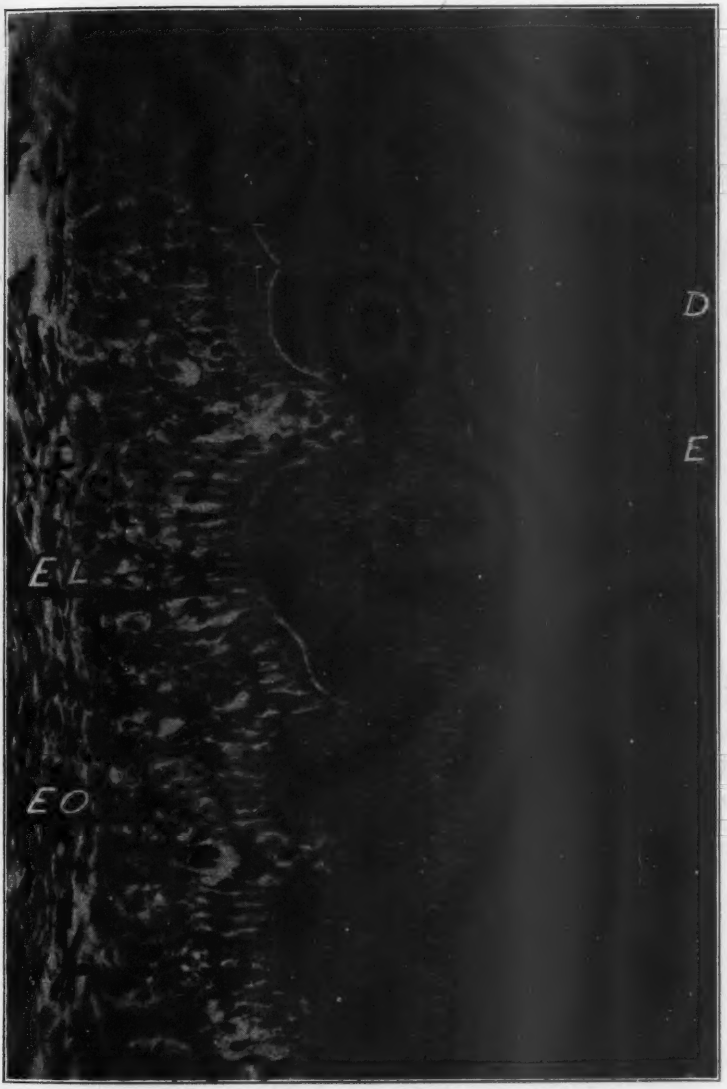

Fig. 8.—Effects on ameloblasts of developing incisor of rat parathyroidectomized and fed a low calcium, high phosphorus diet. *D*, very poorly calcified dentin; *E*, uncalcified enamel matrix; *EL*, ameloblastic layer with disturbed alinement and folding resulting in hypoplasia. The ameloblasts are swollen and disrupted by an edema-like process. *EO*, outer enamel epithelium, proliferation of cells. (Shelling rat No. 1067, age at death, 2 months.) (×300.)

Fig. 9.—Mechanism of production of enamel hypoplasia; effect on ameloblasts of developing incisor of rat parathyroidectomized and fed a low calcium, high phosphorus diet. *EO*, proliferation of cells of outer enamel epithelium. The increased number of cells are a factor apparently in the production of an excess fluid which fills spaces such as at *A*. This fluid seems to penetrate between ameloblasts, causing their separation at *SA* and other points. The nuclei of the ameloblasts are pushed or migrate away from the base toward newly deposited enamel matrix *ND*. (Rat No. 1067, age at death, 2 months.) (×825.)

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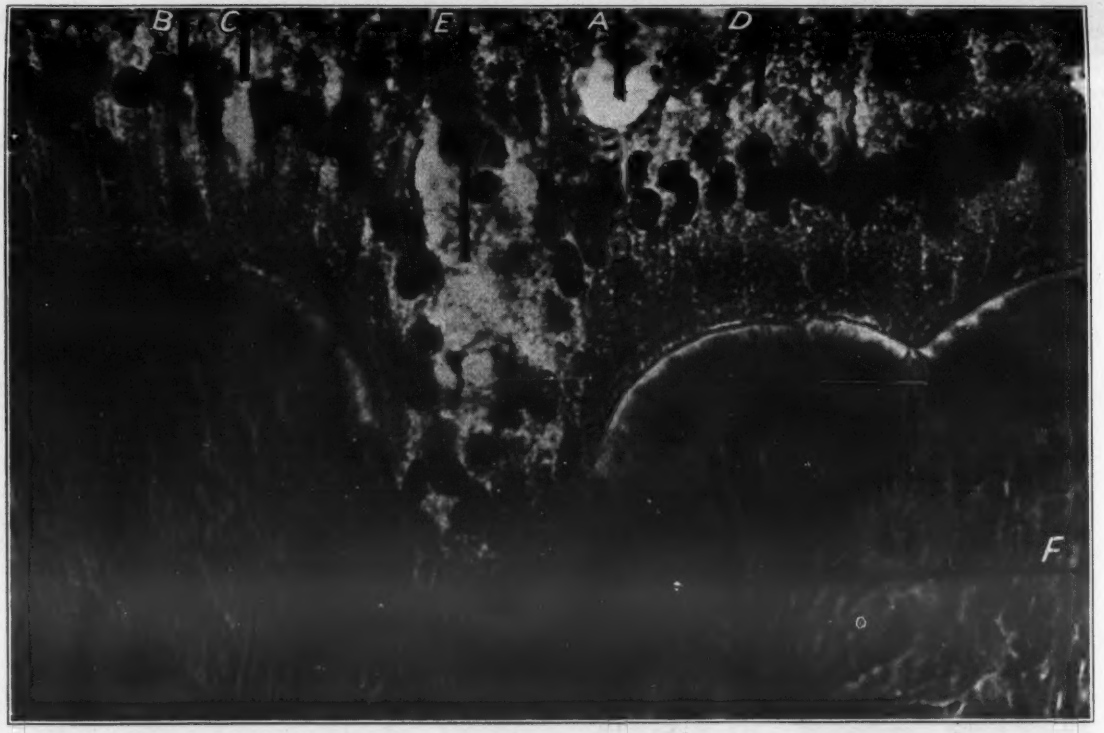

Fig. 10.—Mechanism of production of enamel hypoplasia; effect on ameloblasts of developing incisor of rat parathyroidectomized and fed low calcium, high phosphorus diet; production of spaces filled with clear fluid at *A*. The penetration of this apparent fluid from the outer epithelial layer into the spaces which lie between the ameloblasts causes separation of latter at *B* and *C*. Beginning dissolution and fluid formation is evident at *D*, with beginning migration of the nuclei, and at *E*, the final result of the penetration of fluid and resulting dissolution of ameloblasts, the distorted nuclei only remaining, with resulting defect in enamel matrix at *F*. (Rat No. 1067.) (×825.)

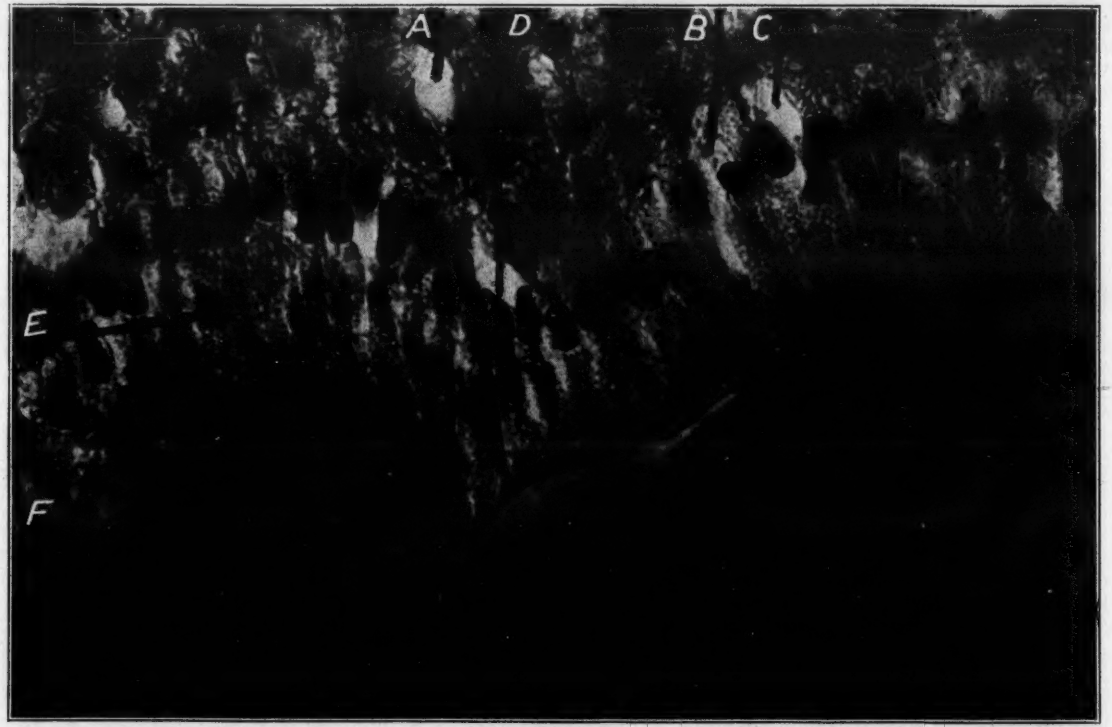

Fig. 11.—Mechanism of production of enamel hypoplasia; effect on ameloblasts of developing incisor of rat parathyroidectomized and fed a low calcium, high phosphorus diet; production of edema-like spaces at *A*. These spaces appear to extend toward the ameloblasts, entering between the individual cells as indicated at *B* and *C*. This causes crowding and pressure, which produces a migration of nuclei at *E* and other points, and at times changes the shape of the nuclei as shown at *D*. Loss of function on the part of disabled ameloblasts results in a defect in the deposition of the enamel matrix (*F*). (Rat No. 1067.) (×825.)

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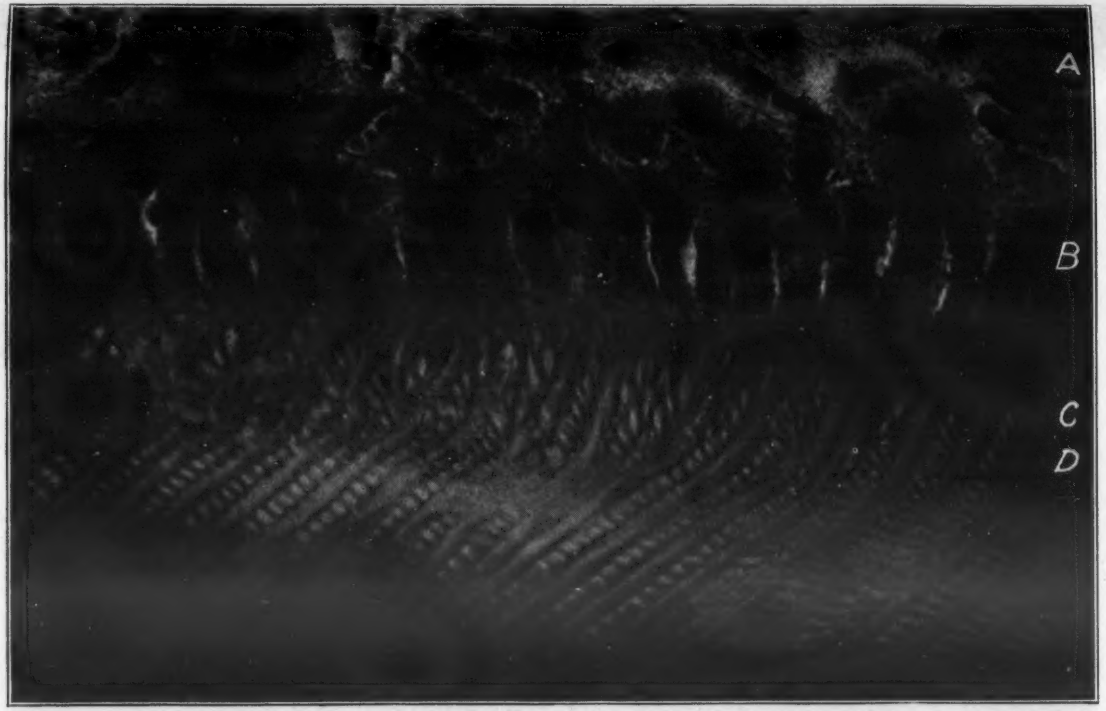

Fig. 12.—Mechanism of production of enamel hypoplasia; effect on ameloblasts of developing incisor of rat parathyroidectomized and fed low calcium, high phosphorus diet, evidence in support of criticism of Gottlieb's interpretation. Changes in the ameloblasts and outer enamel epithelium occur before any change is noted in the enamel matrix. The older portion of the incisor was beginning to calcify when placed under experiment. The enamel rod is being filled with calcospherites at *C*. The interprismatic substance remains as yet uncalcified, at *D*. No gross pathologic change is noted in the enamel matrix, yet a proliferation of cells of the outer enamel epithelium is noted at *A*, with separation of ameloblasts by fluid entering between the cells at *B*. (Rat No. 1067.) (×825.)

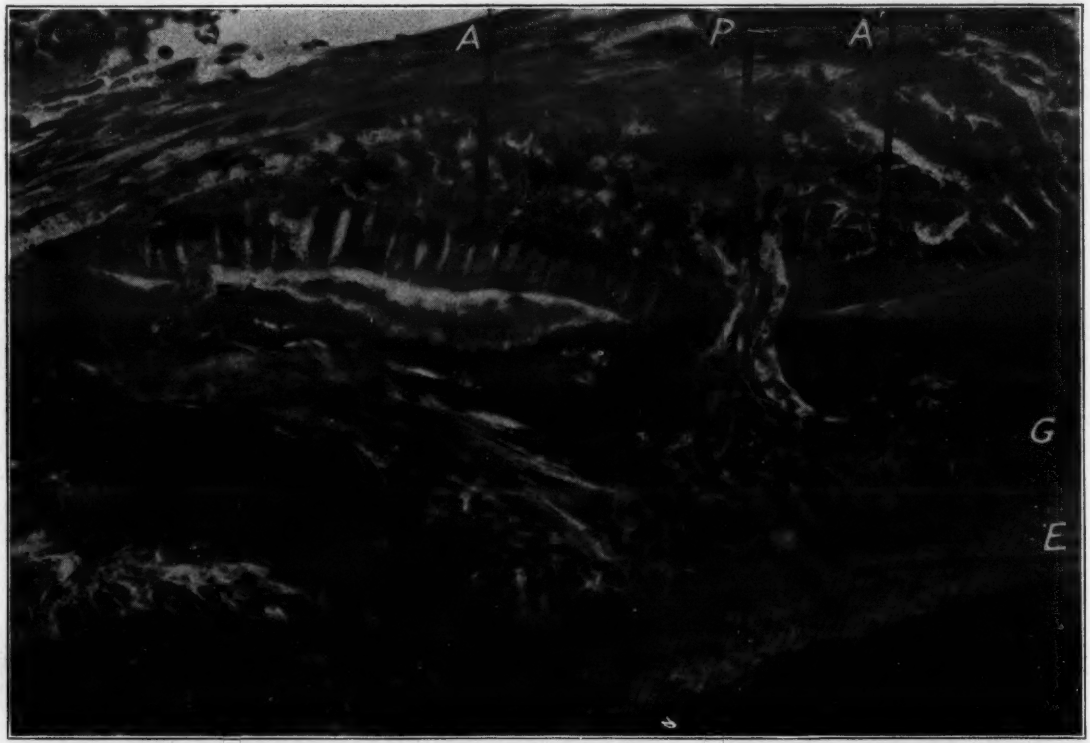

Fig. 13.—Mechanism of production of enamel hypoplasia; effect on cells of outer enamel epithelium of developing incisor of rat parathyroidectomized and fed a low calcium, high phosphorus diet, showing that a part of the process of hypoplasia may be due to pressure which tends to fold and disrupt the ameloblastic layer; excessive proliferation of cells of outer enamel epithelium with separation of the ameloblasts at *A* and *A'*. Proliferation of the outer epithelial cells has caused a penetration through the ameloblastic layer at *P*, from which point the cells of the outer layer continue to proliferate and produce a gellike substance at *G*, which is laid down on the previously formed enamel matrix at *E*. (Rat No. 1067). (×435.)

which point the cells of the outer layer continue to proliferate and produce a gelatinous substance at *C*, which is laid down on the previously formed enamel matrix at *E*. (Rat No. 1067). (×435.)

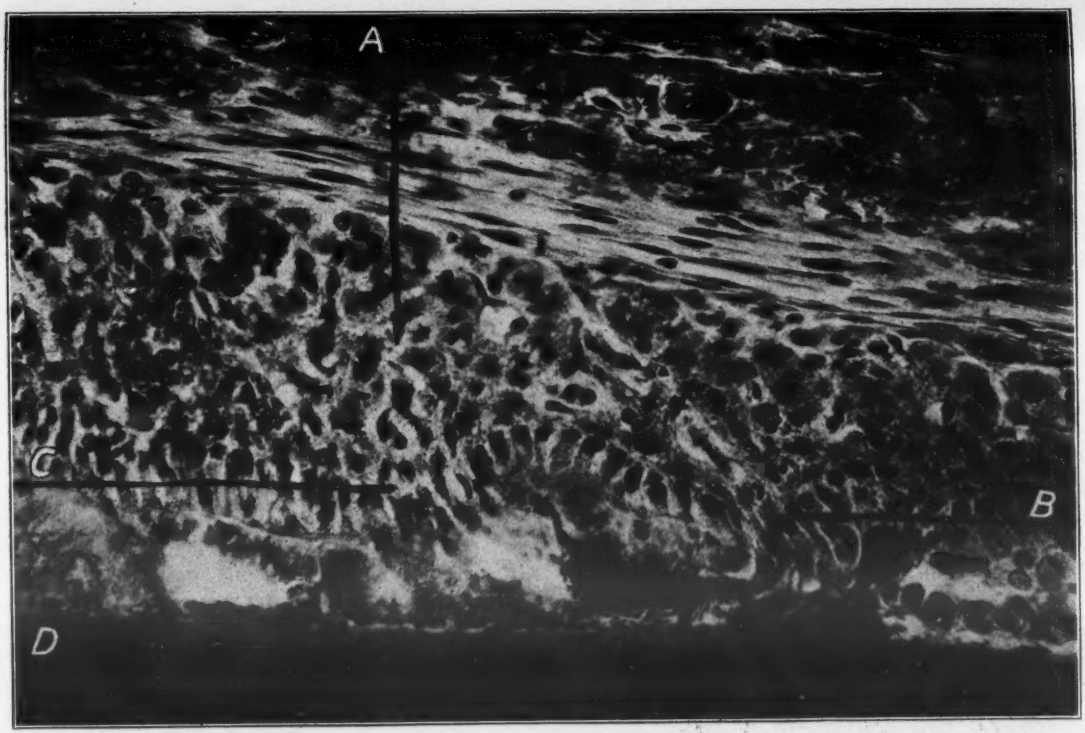

Fig. 14.—Mechanism of production of enamel hypoplasia; effect on the cells of outer enamel epithelium of developing incisor of rat parathyroidectomized and fed a low calcium, high phosphorus diet, showing that a part of process of hypoplasia may be due to pressure which tends to fold and disrupt ameloblastic layer. Proliferation of the cells of the outer enamel epithelium *A* reaches such proportions as to cause penetration through the ameloblastic layer at *B* with continuous proliferation of these cells between the deposited enamel matrix *D* and the ameloblastic layer *C*. Here again is noted beginning separation of ameloblasts by an edematous process. (Rat. No. 1067.) (×435.)

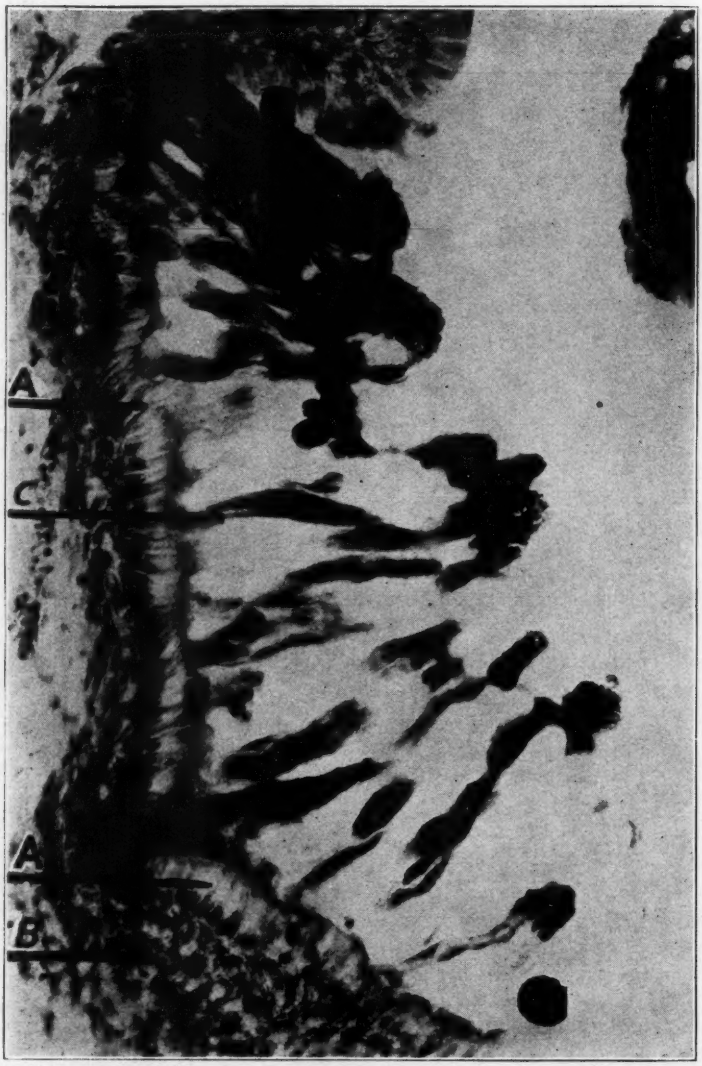

Fig. 15.—Mechanism of production of enamel hypoplasia; effect on ameloblasts of developing central incisor tooth germ of pig on low calcium, high phosphorus (rickets-producing) diet, showing folding of ameloblastic layer due to pressure produced by proliferation of cells of outer enamel epithelium at *B;* swelling and edema between ameloblasts at *A* and *A'*, and abortive attempts of isolated ameloblasts to produce enamel substance at *C*. (Pig No. 9965.) (×300.)

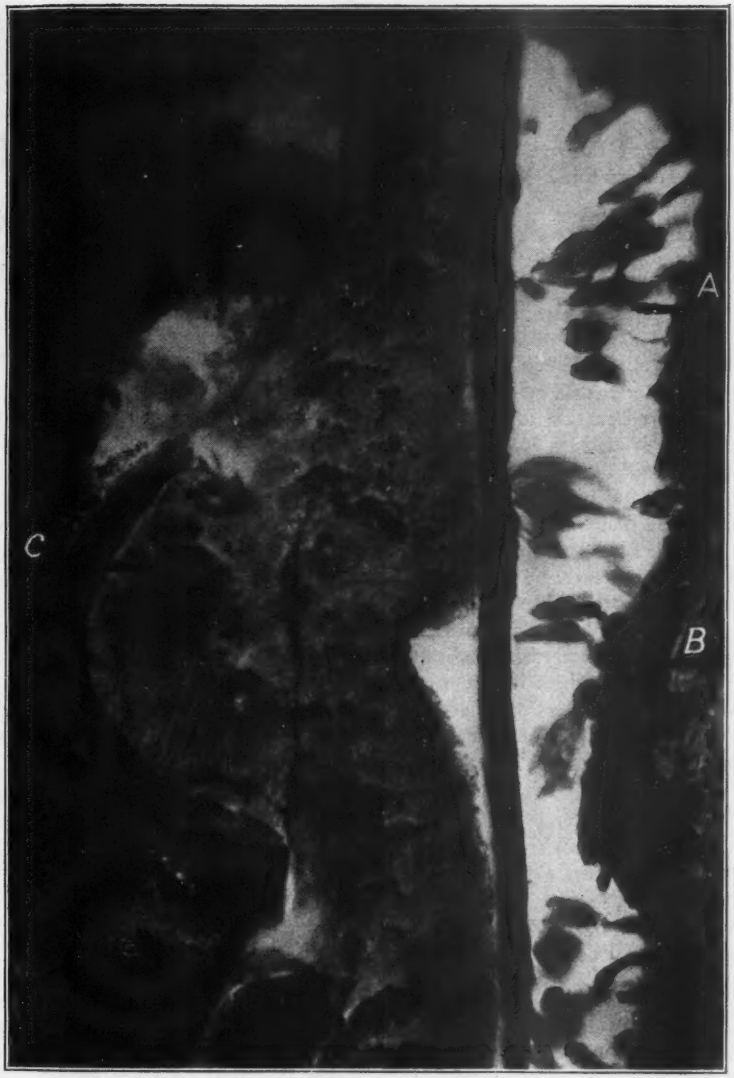

Fig. 16.—Mechanism of production of enamel hypoplasia; effect on ameloblasts and dentin formation of developing permanent central incisor tooth germ of pig on low calcium, high phosphorus diet, showing that part of process of hypoplasia is due to folding, the result of pressure, and not due alone to dysfunction of ameloblasts. At *A* is an abortive attempt on the part of isolated ameloblasts to form enamel substance. Folding of the ameloblastic layer is seen at *B*, and hypoplasia and folding of the dentin are seen at *C*. (Pig No. 76.1). (×210.)

layer, and the outer epithelial cells proliferate and separate the ganoblastic layer from the newly formed enamel substance. These excessive cells are of a squamous type, and in pigs as well as in rats, edema of these cells is frequently seen in the rachitic animals. (Figs. 13-14.)

Sections of tooth germs of rachitic swine show irregularities and disruptions in the ganoblastic layer not observed in control groups. (Figs. 1, 4 and 6.) These irregularities are similar to those found in rats. In certain instances, if irregularities are present, little disturbances of the structure of the individual ganoblasts is noted. In such cases, it would appear that a disharmony exists in relative rates of growth of the ganoblastic layer and the adjacent outer epithelial layer. As a result, folds occur in the ameloblastic layer with little disturbance of the individual ganoblastic structure. (Fig. 4.) That the functioning of the ameloblasts is affected is indicated in those sections in which it would appear that certain ganoblasts are able to produce and direct calcium deposition, while adjacent ganoblasts are unable to perform this function. (Fig. 15.)

That a part of the process of production of enamel hypoplasia is determined by pressure and crowding stresses is indicated in those sections in which many indentations and areas of hypoplasia may also occur in the dentin. (Fig. 16.) A large portion of the process of production of hypoplasia suggests causes which have their origin in pressure effects due to disharmony in rates of growth of adjacent structures.

SUMMARY

The production of enamel hypoplasia in swine and rats is correlated with evidences of pressure effects and tissue proliferation and destruction as follows:

1. Proliferation of the cells of the outer epithelial layer occurs.
2. This proliferation produces pressure which tends to fold the odontoblast and ganoblast layers.
3. The proliferation of the cells of the outer epithelial layer is accompanied by evidence of increased secretion of a fluid-like substance.
4. The excessive fluid-like substance is forced or tends in a direction toward the ameloblastic layer.
5. Evidence of a selective permeability of the ameloblastic layer is observed.
6. The excessive fluid tends to penetrate between the individual ameloblasts.
7. The accumulation of this fluid between the ameloblasts causes their disruption, the nuclei remaining as distorted remnants.
8. Loss of function of the ameloblasts due to the swelling between the cells results in a defect in deposition of enamel substance. Ameloblasts adjacent to this area, but less affected, continue to direct the deposition of enamel substance, thus enclosing the defective hypoplastic area.

CONCLUSIONS

Enamel hypoplasia resulting from the feeding of rachitogenic diets to swine and rats may be traced to a proliferation of cells of the outer enamel epithelium, which produces excessive secretion of a fluid-like substance, that enters between the ameloblasts, causing their disruption and loss of function, defective deposition of enamel substance resulting. This process is accompanied by evidence of disharmony in rates of growth of tooth germs and adjacent structures, resulting in folding of the ameloblastic layer.

POSTOPERATIVE CARE OF SURGICAL PROCEDURES ABOUT THE MOUTH*

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TO each of us who practice any branch of the healing art, two questions come with the presentation of each patient: 1. What is the matter with the patient? 2. How shall I treat his illness? Since no two cases are identical, we must give each case individual consideration and answer these questions to the best of our knowledge and ability.

There was a time in the recent past history of medicine and dentistry in which methods of diagnosis and operative technic had advanced more rapidly than methods of treatment. With a better knowledge of function, pathology and etiology, treatment methods have rapidly improved. In the literature of today, one will find many new and intensely interesting articles devoted to this important subject.

I shall not attempt to cover postoperative care of all surgical procedures about the mouth because many of these procedures are not attempted by men in general practice and would be of but little interest and of no practical benefit to the majority of the dental profession. I shall confine myself to conditions the symptoms of which, in my judgment, the general practitioner should be prepared to recognize, rendering postoperative and advisory service, whether or not he does the operative work necessary in such cases.

In the preparation of a paper on postoperative care, I have found it difficult to omit all surgical technic. Only such surgical technic as is necessary to explain the after-care is mentioned.

Most men are too prone to feel that when the operative procedure is once complete, the chief worry regarding that case is over. This is by no means true. Postoperative care is a very important part of the treatment of most surgical cases. End-results, success or failure in many cases, are good or bad in proportion to the quality of postoperative care given. To give intelligent postoperative care in a surgical case, one must understand the nature and extent of the surgical procedure instituted, and what condition or conditions made the operation necessary, and must have in addition a definite knowledge of the anatomy and physiology of the part or parts operated on.

That prevention is better than cure no one can doubt, and many of the postoperative complications which we are called on to treat might have been prevented entirely or certainly minimized by careful preoperative preparation and careful operative technic.

The operation having been performed, we direct our attention to the two phases of the postoperative care, local and general. The local treatment is directed to

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the care of the wound and adjacent tissues; the general, to that part of the treatment which has to do with the general systemic condition of the patient. Regardless of what operative procedure has been performed, we must always be on the alert for hemorrhage, shock and the symptoms of infection. It is not uncommon to see shock of considerable intensity following the removal of a tooth, and this condition must receive attention immediately. Although much has been written on the cause and treatment of shock, it is often very difficult to explain why it occurs, especially in minor operative procedures. When shock occurs, the patient should be kept prone, warm and quiet, and stimulants be given. The extremities may be slightly elevated. Transfusion should be given if loss of blood has been great. Stimulants may consist of ephedrin, three-eighths grain, and caffein, seven and one-half grains, or digifolin, 2 c.c. intravenously, whiskey or brandy, the latter two being most efficacious if the patient's condition is such that he can readily swallow. (Descriptions of ephedrin and digifolin are to be found in the 1930 edition of New and Nonofficial Remedies.) Fortunately, extreme shock is rare in our work.

POSTOPERATIVE HEMORRHAGE

The nature of the hemorrhage will determine the method of treatment; if capillary, a pressure pack of sterile gauze will suffice in most cases. When the clot is once organized, rarely does further trouble ensue. In recurrent oozing, the oral administration of calcium chlorid, fibrinogen, thromboplastin or ceanothyn may prove effective. I recommend the application of ice bags to the side of the face and neck as routine treatment in all cases except in shock and where pus is definitely known to exist. If these measures prove unsuccessful, suturing the gum tissue, using a figure-of-eight or mattress suture, should produce the desired results. If a number of approximating teeth have been removed, I sometimes suture the gum tissue as one laces up a shoe, using two needles on the same suture, starting the needle point on the socket surface of the gum tissue, crossing from side to side and tightening the suture with one tie; which provides a rapid means of closing a large area, and also an easy, quick way of removal of suture material. To remove this type, I cut the suture where it crosses the socket at which I started it and pick up the tie, when the entire suture will slip out in one piece.

Venous Bleeding.—This is easily distinguished and to protect oneself from the annoyance of night calls and the patient from unnecessary loss of blood, all veins should be picked up and tied or crushed with forceps. If the severed end of the vein is within the bony wall of the socket or process, an effective way to control it is by placing a punch (a broken instrument makes a good punch, or one may use the steel punch used by carpenters to countersink nails) over the bony wall and tapping it lightly with a mallet until the bone is crushed on the bleeding vessel or the bone may be pinched in on the bleeding vessel with forceps.

Arterial Bleeding.—This is more dangerous and more alarming to the patient. Such bleeding following the removal of teeth is rare. It does occur and should be promptly dealt with by tying the vessel where possible or malleting or pinching the bone on it sufficiently to stop the bleeding as in the case of a vein which is severed in the body of bone or process.

Then, of course, one occasionally encounters the typical hemophiliac. Fortunately, they are few and far between, as at present no successful therapy is

known. A few pointed questions in advance of operating will give most experienced operators a clue to such cases. Most people are apt to state that they bleed excessively, that they almost bled to death the last time they had a tooth removed, etc., when they are not true hemophiliacs at all. It is well to listen to and heed such warnings when given voluntarily by the patient or revealed under questioning. When such a history is given, if the patient is not in distress, have a competent physician carefully examine the blood and, if necessary, have the family physician prescribe for the patient. In cases of true hemophilia, have the blood typed and a donor selected in advance of operating.

According to Ordway and Gorham[1]:

Hemophilia is inevitably a menace to life. However slight the trauma and resultant bleeding in this condition, they should be considered very seriously, since frequently they do not respond to well-recognized methods of medical treatment and thereby render the prognosis very uncertain. The tendency to bleed upon the slightest provocation usually manifests itself in early childhood and may continue into adult life. It is believed that if a hemophiliac attains adult life the tendency to bleed gradually diminishes as he grows older. The course, whether of five or fifty years' duration, is at its best a hazardous one. Between attacks of bleeding the hemophiliac may be able to follow the ordinary pursuits of life, or he may be incapacitated partially or completely as the result of joint deformities which are frequent in occurrence.

Macklin[2] states that "only the unaffected males and their descendants can marry with impunity."

Some writers on this subject say that all women in such a family should refrain from having children.

The patient's physician should always be consulted before the teeth of a known hemophiliac are extracted, and operating should be done in a hospital where the patient can be put to bed immediately thereafter and kept quiet, morphin or other narcotics being employed if required. Transfusion is the most effective means of stopping hemorrhages in these individuals, often proving a life-saving procedure.

Ordway and Gorham[3] state that "intramuscular injection of fresh human blood in 25 and 50 cm. once or twice every twenty-four hours has given good results in some cases."

A point to be remembered in connection with transfusion is that the life of the blood platelets is about 3 days. After this time, coagulation time begins to increase, according to Minot and Lee.[4]

CASE REPORT

History.—April 17, 1930, Mr. G. H. B., a school teacher, aged 30, was referred by his family dentist to have lower right second molar roots removed which a dentist had some time previously attempted to remove but without success. The father died at the age of 24, of pneumonia. The mother was living and well. The grandfather died young. The patient had always been considered a delicate child, but had had few childhood diseases. He had always had a tendency to bleed freely even from slight scratches or other skin wounds and had nearly bled to death two or three times. At the age of 13, the temporary upper right cuspid was "pulled out with a string." Profuse hemorrhage ensued despite the fact that all methods known to the family physician and dentist were used to control it. Bleeding continued until the patient was very weak and confined to bed. The family physician and the dentist despaired of the patient's life, but, after seven days of intermittent bleeding, hemorrhage

1. Ordway, T., and Gorham, L. W.: Diseases of the Blood, Monograph, Vol. 9, page 500, 1930.

2. Macklin, M. T.: Heredity in Hemophilia, Am. J. M. Sc., 175:218 (Feb.) 1928.

3. Footnote 1, p. 512.

4. Minot, G. R., and Lee, R. I.: Blood Platelets in Hemophilia, Arch. Int. Med., 18:474, 1916.

ceased and the patient made a slow but uneventful recovery.

Examination.—The weight was from 140 to 150 pounds. The skin was sallow. The joints of elbows and wrists were slightly swollen. The patient said he had "rheumatism." Heart, lungs and abdomen were negative. No glandular enlargement was noted.

The patient was referred to a physician for a thorough physical examination. A report from the physician stated that the blood-clotting time was fifteen minutes. Hemophilia or Schoenlin type of purpura was diagnosed. The physician prescribed for the patient, who was kept under observation and treatment until April 28, at which time the blood clotting time was seven minutes. The physician, a very capable internist, felt it would be safe to remove the tooth.

Operation.—Block anesthesia was administered, and the tooth roots were removed without difficulty. No pus was present. The gum tissue was sutured. Because the crown end of the tooth had been broken off even with the alveolar process some time previously, it was possible to approximate the gum tissue with a figure-of-eight suture. Gauze packs were placed over the wound, and there was no bleeding thirty minutes later.

Postoperative Treatment.—The patient was instructed to go directly to hospital and keep quiet. Instructions had been given the nurse to apply ice and to call the dentist if the patient was restless or in the event of bleeding. Instead of following instructions, the patient took an automobile ride of about 45 miles, going to his home instead of to the hospital. The following day, April 29, he came in at 9:30 a. m., with a history of having bled continuously since 5 o'clock the afternoon before. He was very weak and had fainted a number of times. His condition was so serious that he was unable to walk or stand without assistance. The usual methods of packing were tried with only partial stoppage of bleeding. He was thereupon sent to hospital and the physician was called in consultation. While packing with ferropyrin and the administration of fibrinogen and thromboplastin partially controlled the bleeding, stoppage was not complete. The patient grew weaker.

The following day, April 30, the blood pressure was very low (60). Transfusion was given of 500 c.c. of citrated blood. Bleeding stopped while the patient was on the operating table. He was returned to bed with the condition much improved. No reaction resulted from the blood transfusion. The patient wished to leave the hospital the day after the transfusion, but was prevailed on not to do so.

The following morning, the patient was seen at 8 o'clock. There was no bleeding and he was feeling well. At 9:30, a telephone call stated that he was again bleeding badly. A modeling compound splint, which had been placed in position in the office, April 29, was rushed to the hospital and with a pressure pack placed over the bleeding socket. This temporarily checked the hemorrhage. The patient was seen that afternoon with the family physician. Bleeding continued, blood pressure now being 65. Another transfusion was ordered and 500 c.c. of blood was again given, at 4:30 p. m., May 2, 1930. The hemorrhage stopped while the patient was on the operating table. He was returned to bed in fair condition and the following days were passed without any further bleeding.

Outcome.—May 7, the fifth day after the second transfusion, splint and pressure pack were removed. There was no bleeding and little or no evidence of infection present. Healing had begun and, three days later, May 10, the patient left the hospital in good condition.

The patient has been heard from at different times since that date and was last seen at the office November 1, at which time he weighed 170 pounds. He said that he had been teaching as usual and felt better than he had for a long time.

I am convinced that had the patient obeyed instructions, we possibly might have escaped the post operative worry that accompanied the removal of this tooth. I am also convinced that without transfusion he would have died, as it was necessary to apply very positive pressure to stop the bleeding from the needle puncture of the vein when transfusions were given. Patients suffering with this condition are among the greatest surgical risks. The older the patient, the less the risk.

ACCIDENTAL WOUND IN SOFT TISSUE

Bleeding vessels should be tied off or crushed. Wounds should be carefully cleansed with the antiseptic of choice. I prefer metaphen, 1: 1,000 or 2,000, or a 2 per cent solution of iodin. After a thorough cleansing, if there is a tendency for the wound to gape, edges should be approximated and sutured. For this purpose, I use horse hair, dermal or equisetene silk suture material.

For the tongue and vault and floor of the mouth, I prefer the silk, as it is less irritating to the tongue and will prove effective for from six to ten days if we wish to leave the suture in place that long.

For wounds in the vestibule of the mouth, the same treatment should be carried out, special attention being given to those wounds which extend into the vermilion border of the lip. These should be carefully cleansed, accurately approximated and sutured with the suture material of choice. For these wounds, I prefer horse hair.

Wounds that involve the external surface of the face as well as the mucous membrane should be carefully cleansed and sutured on both skin and mucous membrane surfaces. Seldom is a dressing over small skin wounds on the face necessary. If there is a tendency of the wound to gape and produce tension on the sutures, five or six thicknesses of gauze may be placed over the wound and the ends attached to the skin with collodion. The skin surface should be kept clean and free from crusts. The immediate application of an ice bag and the liberal use of a good antiseptic mouth wash is all that is necessary in most of these cases. Should infection develop, enough sutures are removed to permit drainage. Heat and irrigation should then be used. When drainage ceases, the wound will heal by granulation. If the scar is objectionable, it can be removed later.

Those cases which occur from street or industrial accidents should be given the precautionary treatment against tetanus before operation. Tetanus antitoxin should be administered as soon after injury as possible.

ACUTE CELLULITIS

According to Blair,[5] the most common instance of cellulitis is the swelling of the cheek and floor of the mouth which accompanies ulceration of a tooth. In such cases, if the operator exercises good judgment as to the time and extent of the incision, the postoperative care will be necessary for only a very short period and of no avail. If the proper operative procedures have been instituted early and strict attention is paid to the after-care, a high percentage of patients can be saved.

Incisions for relief of such conditions should be left wide open and filled loosely with gauze for the first twenty-four to forty-eight hours. Heat should be applied, such as by hot magnesium-sulphate compresses or the infra-red lamp. The patient should be fed only fluids and elimination should be good. If at the end of this period, the temperature is down, with no further extension of swelling and induration, the wound may be pulled together in one or more places with sutures. The application of heat continues, the wound being irrigated with hexylresorcinol or metaphen solution and general supportive treatment administered. It is advisable to see that the patient is given plenty of nourishing soups, broths, fruit juices, eggnogs and such soft foods as are easily digested. If the diet is watched carefully, the extreme weakness

5. Blair, U. P.: Surgery and Diseases of Mouth and Jaws, Ed. 3, St. Louis: C. V. Mosby Company, p. 409, 1918.

that usually follows such infections will be materially lessened and convalescence shortened.

If a history of ulceromembranous stomatitis, commonly called Vincent's infection or trench mouth, is obtained, or if the presence of such a condition is suspected because of the odor of the breath or the discharge when the tissue is incised, a smear should be made immediately and examined for the possible presence of Vincent's spirochete and fusiform bacillus. Should they be found, an intravenous injection of arsphenamin should be given at once. Two of my cases proved to be of this type, and recovery was prompt in both cases under the foregoing treatment.

As the discharge and swelling decrease, the edges of the wound should be gradually brought together with narrow strips of zinc oxid tape. Collodion may be used on the ends of the strips. The scar will be lessened considerably by this procedure. If the scar is objectionable, it can be removed later, but sufficient time should be allowed before its removal is attempted.

CASE REPORT

History.—C. S., a girl, aged 7 years, first seen in consultation with the family physician at her residence, had a temperature of 104, pulse rate, 132, and respiration, 36 and difficult. The mother said the child had had a foul breath about ten days before, with bleeding gums. The family dentist had prescribed a mouth wash for this condition. After using it two or three days, the child no longer complained and the mouth wash was discontinued. The child had complained of headache, seemed very feverish for the past forty-eight hours, had had a severe chill the night before and also complained of the throat hurting.

Examination.—The tongue appeared to be thick. The neck was now badly swollen, hard and boardlike in appearance. The patient could not swallow fluids, and breathing was difficult. She was sent to the hospital. A blood count revealed 28,000 white cells. The urine was normal except for acid reaction.

Operation.—An operation was performed at once, an incision being made from the tip of the chin to the hyoid bone, then to right and left to the outer borders of the induration. There was considerable serofibrinous fluid discharge from these incisions, having a typical odor associated with ulceromembranous stomatitis or Vincent's infection. Smears were made which showed an abundance of Vincent's spirochetes and the fusiform bacillus. Intravenous injection of arsphenamin was given by the family physician while the patient was on the table. The wounds were left wide open, packed loosely with iodoform gauze and hot magnesium sulphate compresses were applied. Two hours later, the patient was given fluid, which she swallowed with some difficulty. Twenty-four hours later, she said she felt well. The temperature was 99.6; pulse, 100; respiration, 24. Forty-eight hours after operation, the temperature was normal. Under gas-oxygen, three sutures were placed in the wound, bringing the edges almost together, but leaving sufficient space for cigaret drains in each side. The following day, sulpharsphenamin was given intramuscularly. Four days later, the drains were removed and the child was allowed to go home.

One week later, the patient was dismissed, and, the following week, she returned to school.

LOCAL OSTEITIS OR DRY SOCKET

One of the most annoying conditions following extraction of teeth is the so-called dry socket. Every precaution should be exerted to prevent this condition. Much of the postoperative complications following extraction of teeth could be eliminated if the patient's mouth was properly cleansed, acute ulcers healed and infections eliminated before the operation is attempted. If it becomes necessary to remove teeth in the presence of filth in the mouth or a diseased condition of the gums and other tissues, we must be doubly careful regarding postoperative care. Failure to remove from the tooth socket particles of tartar de-

posits or pieces of filling material, or to remove sharp spines of process, often causes the dentist considerable worry. When there are in the mouth ulcers that suggest Vincent's infection, extraction should be postponed if possible. If extraction must be done without delay, it is advisable to use one of the many prescriptions available, such as Fowler's solution (solution of potassium arsenite, U. S. P.) in peroxid. Although other formulas may be equally efficacious, the prescription I usually use is as follows: wine of ipecac, 6 drams; liquor potassii arsenitis, 10 drams; glycerin, 10 drams; hydrogen peroxid, to make 16 ounces. This is used every two hours as a mouth wash. A poison label should be pasted on the bottle and patient instructed not to swallow the mouth wash when using it to rinse the mouth or to gargle.

I am sure that most men, regardless of how careful they may be, are at some time called upon to treat dry sockets. To treat wounds in the bone intelligently, one should have an understanding of what takes place when the bone is injured through accident or operative procedure.

As early as 1730, Belshire, an English surgeon, called attention to the osteogenic function of the periosteum. This fact was commented on by Duhamel, a Frenchman, in 1739. Haller and John Hunter opposed this view and said that bone was deposited by blood vessels. Sir James Syme, a surgeon of Edinburgh, pointed out that scientific physiology and pathology must be combined for clinical observation and experiment. He also determined the osteogenic function of the periosteum in his experiments on dogs.

Goodsir was probably the first to determine by means of the microscope that only the osteoblasts are concerned in bone formation and that the same type of cells exist and function in the bone structure. From that period to the present time, most surgeons and experimental workers have agreed that from the proliferation of the osteoblast, we have new bone formation.

Weatherhill states that the embryologist, the anatomist, the physiologist, the surgeon and the pathologist agree that the periosteum is not only a source of nutrition for the bone, but that it also possesses definite osteogenic function.

Puterbaugh[6] says:

> **Bone as a tissue has very poor reparative power. Since it cannot proliferate capillary loops as does the peridental membrane, the primary coagulum which forms in such wounds undergoes liquefaction necrosis, the surface bone undergoes inflammatory reaction and healing gets underway very slowly.**

There is considerable divergency of opinion as to the exact process of bone repair or bone regeneration, but it is fairly well agreed that it is accomplished by a special cell, the osteoblast. The necessity, therefore, for protecting the periosteum is apparent.

According to Endleman and Wagner,[7] the peridental membrane that lines each healthy tooth socket is very closely related in its histologic structure to the periosteum; therefore, it should be respected and preserved as far as possible. With the foregoing facts before us, it becomes our duty to protect the socket from contamination and unnecessary trauma so that we will have the best possible chance for normal formation of the blood clot. Patient should be instructed not to rinse the mouth for at least three hours after the tooth has been removed. Yet, with all of our precautions, this

6. Puterbaugh, P. G.: Removal of Impacted Teeth, J. A. D. A., 17:711 (April) 1930.

7. Endelman, Julio, and Wagner, A. F.: General and Dental Pathology, St. Louis: C. V. Mosby Company, 1920, p. 402.

so-called dry socket condition will occasionally occur. At least, this is true in my practice.

When the blood clot is lost, the socket should be thoroughly but gently irrigated with a warm saline solution, a warm solution of hexylresorcinol or a solution of metaphen. The socket is then walled off with sterile gauze packs and dried with a small ribbon of sterile gauze. If it is extremely painful, it may be advisable to use procain in powder form in the socket after it has been dried. The exposed bony wall of the socket can then be painted with a 10 per cent solution of silver nitrate until the bone has been impregnated with sufficient silver to become thoroughly discolored, after which a sterile ribbon-selvaged gauze is placed, *not packed,* in the socket. This gauze can be saturated with a solution of creosote, guaiacol and glycerin, a camphorphenol solution or other agents of choice. While I have used the silver nitrate method, I do not recommend it in all cases. I prefer drying the socket as above mentioned and placing a ribbon of selvaged gauze saturated with a solution of creosote, guaiacol and glycerin in the socket and dismissing the patient for from twelve to twenty-four hours. If this treatment is repeated every day for a few days, most patients will report that they are comfortable, and granulation tissue can be noticed in the socket, which, if protected and touched very lightly with a curet, will bleed sufficiently to fill and protect the socket.

Some men recommend the application of guaiacol and glycerin, equal parts. This has never proved so satisfactory as other agents in my hands. Other men have from time to time recommended curettage of the socket until a free flow of blood is established with the hope that this second clot will stick, as they say. I do not think such a procedure is good practice. Since the first clot was lost primarily because of infection or loss of peridental membrane, there is less likelihood of the second clot becoming thoroughly organized; and, again, such a procedure opens up fresh bone to possible infection, with end-results that are unpleasant for all concerned.

If only a portion of the blood clot is lost, careful cleansing of the wound, not dislodging the remaining portion of clot, and the application of the selvage ribbon of gauze saturated with the solution of creosote, guaiacol and glycerin will, in most cases, prove effective. Dressings of such sockets should continue until healthy graulation has covered all the exposed bone and the patient is free from discomfort.

A considerable percentage of operators use cotton as a medium of conveying medicinal agents to infected sockets or to absorb moisture or blood from a socket. It is my opinion that cotton should not be used for this purpose and that this practice is responsible for some unpleasant conditions arising, since the cotton fibers may be left on the bony wall of the socket and escape the notice of the operator and interfere with organization of the clot.

At no time should a gauze dressing be packed tightly into a socket. The word "packed" is often used improperly, since the operator in most cases is really dressing the wound instead of packing it. Packing implies that pressure is used, and surely pressure is not needed in an already infected socket. Packing is necessary only in cases of hemorrhage and to maintain the normal anatomic position of the tissue.

In extreme cases, it may become necessary to prescribe some form of sedative to give the patient relief and sleep. In such cases, there is no objection to prescribing

amidopyrin, codein or morphin, separately or in combination with other drugs, to produce the desired results. The combination which gives good results in severe cases in my practice is codein, one-half grain, acetylsalicylic acid, 5 grains, at bedtime.

General systemic treatment should not be overlooked. The patient should receive plenty of nourishing fluids, fruit juices and alkalis. Faulty elimination should be corrected.

One should not confuse the dry socket symptom complex with that of acute osteomyelitis. In dry socket, local treatment gives relief for a few hours at least; in acute osteomyelitis, local treatment affords little or no relief. In dry socket, the application of heat is soothing; in acute osteomyelitis, the reverse is true. In dry socket, the external surface of the bone is rarely very tender to pressure; in acute osteomyelitis, one of the most characteristic diagnostic symptoms is extreme pain under continued pressure. Ordinary doses of sedatives will give relief in dry socket; in acute osteomyelitis, these are worthless. In dry socket, the blood picture will be practically normal, in osteomyelitis, the white and the polymorphonuclear cell counts are very high.

I am convined that if we were more thorough in our examinations and more careful in evaluating the existing conditions before operating, and then observed the principles fundamental to good surgery, we would have fewer of these unpleasant cases to treat. I have no quarrel with the man who is able to diagnose instantly or the man who operates rapidly, provided his judgment is uniformly good and his speed is not a primary consideration. In the final analysis, end-results count.

OSTEOMYELITIS

If osteomyelitis of the bones of the face is diagnosed early and correct surgical procedure instituted, one should then adopt a conservative program in the treatment. McCurdy[8] states that the destruction of bone is irregular and repair is also irregular and coextensive with the preservation of the periosteum and endosteum. McCurdy also states[9] that osteomyelitis occurs four times as often in children as in adults.

Local Treatment.—Heat should be applied and the wound irrigated three or four times daily with hexylresorcinol or metaphen. Formation of new pockets of pus should be watched for and prompt drainage established if they occur. Sequestra are only removed when loose. Acutely infected bone is not curetted.

Blair and Ivy[10] state:

> It is better to remove small portions from time to time than to do a radical operation too early. In this way, the osteogenic cells are more likely to be preserved for the formation of new bone, and less disfigurement results. If new bone be allowed to form coincidently with destruction of the old bone, the continuity of the jaw is preserved and pathologic separation or fracture through the diseased area is not so liable to occur.

Sequestrum may be left when acting as a splint, provided the general condition of the patient is good. Pus should be examined, and local systemic treatment given to destroy the virulency of predominating organisms if possible.

General Treatment.—Plenty of nourishing liquids, fruit juices and alkalis are given. Faulty elimination is corrected. Calcium may be given intravenously or

8. McCurdy, S. L.: Oral Surgery, Pittsburgh: Pittsburgh Dental Publishing Company, 1923, p. 173.

9. Footnote 8, p. 171.

10. Blair, V. P., and Ivy, R. H.: Essentials of Oral Surgery, St. Louis: C. V. Mosby Company, 1923, p. 247.

orally; and tonics, such as iron preparations given hypodermically, eggnog and brandy. The patient is kept in the sunshine as much as possible. Do not get impatient to get the patient well. When the final sequestrum has been removed, the discharge will cease and the wound heal by granulation. By this time, sufficient new bone will have been formed in most cases to give good functional results. If sufficient new bone has developed and the sequestrum still remains in place, it may be removed by opening the soft tissue and new bone covering it and lifting it out of its bed, after which the wound will heal promptly. If scars are objectionable, they should be removed later.

FRACTURES

Most fractures are the result of direct violence, accidental or intentional, and, in most cases, they are complicated by other injuries. Immediate postoperative care will be determined by the extent of the injury or injuries. In the absence of shock, ice packs should be immediately applied after the fragments have been placed in position. Application of ice is continued during waking hours for the next three or four days. After this time, if there is no evidence of abscess formation, the use of ice may be discontinued or it may be applied intermittently.

Special attention should be given to keeping the mouth and teeth clean. The mouth should be rinsed, then sprayed with an antiseptic solution three or four times daily. The mucous membrane should be watched carefully for possible Vincent's ulcers, and should this condition develop, immediate treatment should be instituted.

In a considerable percentage of all fractures of the mandible, abscesses will develop under the lower border of bone at the fracture line. These should be promptly incised and adequate drainage maintained until the discharge ceases. Roentgenograms should be made frequently to determine the extent of new bone formation or possible disintegration of the bone through infection.

All sinuses occurring through incisions or otherwise should be gently irrigated sufficiently to cleanse the wound three or four times each day. Excessive pressure when irrigating tends to spread infection and increase the possibility of dislodging an embolus, which might prove fatal to the patient.

The age-old habit of probing such wounds should be discouraged. Roentgenograms taken at the proper angle will disclose more than one can find out by means of a probe. Nature's method of replacing bone should always be kept in mind in treating such injuries.

When a portion of the bone has been exfoliated as a sequestrum, it should be removed, except in those cases in which the sequestrum is acting as a splint and the general condition of the patient and drainage from the wound is such that the systemic effect is negligible.

According to Blair,[11] "If the full thickness of the jaw becomes necrosed the sequestrum is not removed until enough new bone has been deposited by the surrounding periosteum to form a ridged casing at the gap."

Berger[12] states in this connection that "conservative operative procedure cannot be overemphasized."

CASE REPORT

History.—Mr. J. H., aged 45, a broker, and of athletic type, was first seen at the hospital, May 14, 1927, eight hours after an automobile accident which occurred about 60

11. Footnote 5, p. 399.

12. Berger, Adolph: Principles and Technique of Oral Surgery, Brooklyn: Dental Items of Interest Publishing Co., 1927, p. 130.

miles outside the city. The patient was unconscious, his condition critical. The face and neck were badly swollen, and there was bleeding from the mouth and lacerations under the point of the chin.

Examination.—Hurried examination revealed multiple compound fractures of the mandible, and one fracture line through the left mental region and one through the symphysis. The angle and right side of the mandible were displaced inwardly. The patient was extremely cyanotic, breathing becoming more difficult every minute.

Operations.—The neck was painted with iodin, and a low tracheotomy incision made. There was little bleeding. No anesthesia was used, and forceps were inserted. The patient began to breathe through this opening, struggling violently, and displacing the forceps. The wound closed, and the patient became cyanotic again. By this time, the tracheotomy tube had arrived from the operating room floor, four floors above. The tube was dipped in iodin as a means of sterilization, wiped with sterile gauze, inserted and attached to the skin with zinc oxid tape. The patient was now breathing and tossing around on the bed, not struggling as he was when the trachea was first opened. One-quarter grain of morphin was given hypodermically. The patient soon returned to consciousness and tried to talk. Ice packs were applied about the face, and he was propped up in bed.

The following day, May 15, roentgen-ray examination revealed a fracture through the left mental region, fracture through the symphysis, two fracture lines in the region of the right angle of the jaw, one beginning just posterior to the second molar, and running downward to the lower border of bone. The other fracture line started one-half inch posterior to the one just described and ran posteriorly through the ramus just above the angle.

May 19, under local anesthesia, the fractured segments of bone were approximated and immobilized, the Blair-Ivy intermaxillary wiring being employed. When the triangular segment of bone, including the right angle of the jaw, was placed in position, it acted very much like a keystone in an arch and prevented the ramus from being displaced forward and upward. The patient was fed fluids and his position in bed changed often to prevent pneumonia developing.

Course.—May 25, the swelling had subsided considerably. Roentgenograms made on this date showed "fragments of bone in good position."

May 26, the tracheotomy tube was removed and the wound allowed to close.

May 29, an abscess under the right angle was incised under local anesthesia. This continued to drain as long as the patient was under the dentist's care.

June 5, further roentgenograms were made which showed the fragments in good position, with some disintegration at the lower border of the triangular segment of bone with a beginning formation of new bone at various fracture lines.

June 15, the patient was allowed to leave the hospital. At this time, he was able to walk around, was free from temperature and was feeling well. He made regular visits to the dental office for the next two weeks. Roentgenograms made June 25 showed steady progress of the destruction of triangular segments, also steady progress in new bone growth. The wound under the angle was still draining.

The patient failed to keep the next appointment and was next heard from in another city, where he had been operated on for the removal of dead bone. He stated that he had been persuaded by his wife to seek the services of the physician under whose care he now was and who had operated on him because his wife knew that "dead bone should not be left in his jaw." (Quoted from patient's letter.)

Outcome.—Five and one-half months later, he wired for an appointment. When he came in, the median line of the chin was displaced to the right, and there was considerable concavity on the right side of the face at the angle of the jaw and in front of the ear. When the patient opened his mouth movement of the mandible was decidedly to the right, with no movement of the right condyle. There was no occlusion of the teeth except the lower left molars, and here it was imperfect. Roentgenograms made at this time, December 3, showed the ramus and coronoid process drawn forward and upward under the zygomatic arch against the malar bone, with no union between this portion and the body of the bone. The patient now regretted that he had taken his wife's advice and wanted a bone graft or, as he said, "anything to fill up

this cave in my face and fix me so I can eat."

After explaining the difficulty of such a procedure, I advised him to seek help elsewhere. I heard from this man in January, 1929, and his condition was unchanged.

It is my opinion that had the right angular segment of bone been left in place, new bone would have continued to form so that, at the proper time, sequestrum could have been removed without the bad deformity and the resultant loss of function.

Do not let the patient or any one else influence you to remove a sequestrum until you are sure such a procedure is correct. A pathologic fracture may be the result. See that adequate drainage is maintained and allow nature to assist. If this is done, we will have less deformity and better functional results in fracture cases.

I am sure I have had my share of difficulty in the handling of such cases as are mentioned in this paper. Not all of my patients have been cured nor do I expect all future patients to be. I do feel that we owe patients the very best of our efforts and that they have a right to expect us to keep ourselves informed so that we shall be able to render that which is best in their particular case when we are called to serve them.

THE ECONOMIC ASPECTS OF PREVENTIVE DENTISTRY*

By EDWARD J. RYAN, B.S., D.D.S., Chicago, Ill.

BEHIND all great social movements —be they concerned with the world of practical affairs, of esthetic interest, of ethical concepts—is a philosophy. This philosophy represents the attempt to give meaning or value to a situation. Whereas science is concerned with analytic description, philosophy is concerned with interpretation. Durant tells us that "to observe processes and to construct means is science; to criticize and coordinate ends is philosophy. . . . Science gives us knowledge, but only philosophy gives us wisdom." The philosophy of the prevention of disease implies an attempt to establish an ideal, that is, a mental concept of a hoped-for practical state. The ideal of preventive dentistry, then, is the creation of a condition of human life where no dental disease exists. Toward this end, our philosophy directs and stimulates our science.

If the prevention of disease needs any justification, it might be well to turn to the words of the philosopher John Locke. In the year 1692, Locke published his monumental work, "Some Thoughts Concerning Education," which begins:

> A sound mind in a sound body, is a short but full description of a happy state in this world. He that has these two, has little more to wish for; and he that wants either of them, will be but little better for anything else.

In short, the prevention of disease is concerned primarily with the preserva-

*Read before the Section on Dental Economics at the Midwinter Clinic of the Chicago Dental Society, Feb. 4, 1931.

tion of health, from which springs a large measure of men's happiness.

Unfortunately at the now, the present, the contemporary state of dental science, there are few specific causes and still fewer specific cures for dental disease. Of theories and hypotheses, there is no end; of proved facts and uncontrovertible evidence, there is little. The exact cause of dental caries is unknown, the etiology of much periodontal disease is still obscure, the causation of mouth-tissue malignancies remains a mystery. At the best, our methods of prevention are empiric. That is, our methods are based on experience or observation and not on a complete understanding of underlying causes. It is necessary that we make plain to our patients that our services of prevention produce excellent results and much good, but as long as first causes are unknown to dental science, we cannot guarantee absolute prevention. It is the same old story: indicating to our patients the limitations of dental treatment and emphasizing that the phenomena with which dentistry deals are biologic. Truth telling is the foundation of all long-term professional and economic success.

A critical study of the economic aspects of preventive dentistry requires a great deal more than the mere consideration of practices profitable to the dentist. The economic advantages to the public—which are measureable in terms of health values, the conservation of time and money saving—must never be lost sight of. If in the health education of the public on dental matters, the major emphasis is on the profit to the dentist, a dismal failure may be predicted. On the other hand, if emphasis is laid on the public's profit from a program of prevention, we may expect a larger measure of success.

A study of the economics of preventive dentistry requires much more than the presentation of preventive services to the individual patient in the dental office. As in all problems of public health, the battle against the forces of mass ignorance, fear, superstition and apathy is of great importance. The projection of the idea and the ideal of preventive dentistry into the consciousness of the public is a problem in adult education. C. E. A. Winslow of Yale University has said:

> The public-health campaign of the present day is, therefore, based on a broadly conceived program of adult education. It uses, with more or less persistence, the newspaper, the health department bulletin, the special leaflet, the lecture, the radio-talk, the cinema, the poster, the exhibit.

A consideration of this important subject of adult education is not within the scope of this paper. It is enough to say in passing that, within the next few years, we must break free from some of our traditions and antiquated ethics and, as an organization, tell the true story of dentistry to the public. Of the dangers that are lurking here, we must be fully aware. A publicity campaign poorly organized, blunderingly promoted, undignified, might defeat the very purpose for which it was intended. That is, by crude methods of advertising, we might innocently enough place ourselves, in the public eye, in the same category as the advertising dentists, who have always been anathema to the intelligent public and the ethical members of the profession. Let no one interpret these remarks as a statement against the basic idea of public education in dental matters. With the idea of public education, we most enthusiastically and whole-heartedly agree: the manner and method of appeal to the public is the important thing. We should hesitate before we use methods which might jeopardize our position or undermine the public's confidence in the dental profession.

The road toward the more general practice of preventive dentistry is blockaded by two serious obstacles: first, the indifference and the apathy of a large number of the profession; and, second, the ignorance of the public. It would appear almost axiomatic that before we can make progress in public education, we must first do considerable missionary work within the profession. In these times, when one hears so much talk of making the public "dental-minded" and "dental-conscious," it might be well to hesitate and direct more vigorous effort toward the education of the profession in the importance of preventive dentistry. It is quite conceivable that the public might become educated up to a level of desire for dental services which large numbers of the profession could not or would not satisfy. To be specific: Mothers, alert and well informed, after reading of the importance of early dental care, have often taken their children to some dental office, to be met with this sharp rebuff: "Baby teeth need no attention." And, too often, adults, learning from various sources of the dangers of dental infection, have stepped into a dental office to be told that: "X-rays are not necessary," or "All this talk of infected teeth is a fad of physicians and dental alarmists."

The abysmal chasm that exists between the theory of prevention and the practice of prevention as it relates to the profession and to the public is appalling. The professional literature is full of worthwhile suggestions regarding procedures and practices directed toward prevention and the health significance of dentistry. Our meetings, for the most part, are of a high scientific and professional character. The practice of dentistry has not kept pace with the philosophy of dentistry. Arsenic devitalizations, "tin-can" crowns, amalgam slugs, occult diagnoses still make up too much of the practice of dentistry. The indifference of the public to prevention is largely the reflection of the apathy and lack of enthusiasm of the profession. The classic slogan of Glenn Frank, "Millions for pills, but not one cent for prevention," presents a vivid picture of a common public attitude.

Preventive dental service has an important economic aspect. The profession has been slow to grasp the economic self-profit of a program of prevention; the public has not been impressed with the economic advantages of preventive dental service. The economic improvement of dentists should follow whenever they escape from the tether of the vicious triumvirate: materials, merchandise and mechanics, and begin to place the emphasis on health, biologic processes and prevention. And of this there can be no doubt: the public likewise will profit when the dental profession becomes biologic and prevention minded.

The prevention of dental disease is the professional ideal of dental practice. And none have ever found an argument against the ideal of prevention except a few shortsighted dentists who feared that prevention might some day become so nearly perfect that their services might no longer be necessary. But such a dental millennium, unfortunately, is very dimly in the future. The indifference of patients is the great obstacle to prevention. In theory, almost every patient accepts the thesis that prevention is far better than cure; but, in practice, most patients are chance-takers and prefer not "to cross the bridge before they come to it." Patients in the throes of dental pain will rush to a dentist for relief and those unfortunates with disabled and crippled mouths will spend large sums of money for restorative dentistry. Dental pain and mutilation are largely preventable;

it is our duty and to our profit to force these truths on the consciousness of our patients.

Like all sound economics, the practice of preventive dentistry is mutually profitable; the patient preserves his denture and the dentist increases his income. Over and beyond the biologic preservation of the human denture, the patient enjoys a three-fold profit from preventive measures: he avoids the inconvenience and the drain on efficiency that comes from dental pain and infection; he conserves his time by not being required to spend long hours in dental treatment, and he saves large sums of money by coming frequently for prophylaxis and the treatment of incipient disease conditions rather than waiting until expensive and extensive restorative dentistry is demanded. The dentist who practices preventive dentistry is assured of a steady and larger flow of income by the frequent return of patients, and he enjoys the mental satisfaction that comes from the knowledge of a job well done. As the advertiser says, "Repetition is reputation," so let us repeat over and over again and drum into our patient's consciousness this truth: *Neglect costs more than treatment; in pain, in time and in money.*

There are four general dental conditions which preventive service is to be directed toward; namely, malocclusion, dental caries and the possible pulp sequelae, periodontal disease and mouth-tissue malignancies. Preventive service is to be carried out from the "cradle to the grave." In childhood and early adult life, our services are directed toward the prevention of malocclusion and caries. In the middle decades, we are chiefly concerned with the prevention of disease of the periodontal tissue. In the later years, we are concerned with the dangers of malignant neoplasms. Our services are concerned with the whole life span of the individual. We need never fear that our services will ever be unnecessary; ours is a lifetime job.

MALOCCLUSION

To prevent malocclusion, the child should come to us early and often, deciduous teeth should be preserved, and the pernicious habits of mouth-breathing, thumb-sucking, pillowing, etc., should be corrected. Our job is not altogether mechanical or manipulative. The child brought to us for observation and examination is coming for our knowledge and advice. We are not talking of orthodontia, but of prevention of the need for orthodontia. The general practitioner should recognize the forerunners of malocclusion and attempt to intercept it. For his knowledge and judgment, he is entitled to a fee. The advice that we give the mother regarding dietetics and its relationship to the dental structures, the measures which we apply to the correction of vicious habits, the great care which we exercise in the treatment of a deciduous tooth to preserve the totality of the deciduous dentition are important services which we cannot give away. If we evaluate our services and set our fees in terms of grains of alloy, pennyweight of gold and quantities of cement, and do not receive pay for our knowledge and advice, we are apt to be inclined to do only the mechanical or profitable thing and let the advisory or unprofitable thing slip. Knowledge and information which it has taken of our time and money to acquire cannot be given away. It is a question of profit and loss. If we give of our knowledge, the patient profits and so should we; if we withhold important information, the patient loses and so do we. Let us give more time and study to the problems of the interception of maloc-

clusion—and be paid for it. No other professional man gives his "brains" away.

DENTAL CARIES

Caries is one of the prices which man pays for becoming civilized. In these days when scientists speak in terms of emergent evolution, we may look on dental caries as an expression of this principle. As man evolves from the primitive to the civilized, the ratio of caries increases in direct proportion to his ascent. Witness the comparative freedom from caries in the mouths of the Australian bushman and the Eskimo as the representatives of primitive types, and the rampant caries in the mouths of our movie-going, roadster-riding, roadhouse-dancing, American young people. Dental caries viewed in this light takes on a social significance; and if we may reason by deduction, we may expect the incident of caries to increase as civilization becomes more complex, unless the services of preventive dentistry become more effective. Considering this type of dental disease in its broadest light, we understand it as a condition that appears to attack man in the higher brackets of civilization. To defeat these tendencies, we cannot hope nor do we wish to reverse the process of evolution. What we hope to do is to find the thing or things in modern man's life and habits which make him susceptible to the ravages of dental hard-tissue disease. Somewhere in the domain of bacteriology, immunology, endocrinology, biochemistry, we may find the answer to the riddle. Until we find a specific one, we must continue to practice preventive dentistry empirically. We must instruct our patients in mouth hygiene and dietetics; we must practice good surgery in our operative dentistry and prophylactic treatments; for all of which, we must be paid.

All programs of prevention emphasize the importance of education. Through the medium of the written word and the spoken word and by pictorial methods, the public is appealed to. The public is asked to help in the prevention of forest fires, traffic accidents, disease. Even now, the effort in the field of dentistry is more commercial than professional. The dentifrice, mouth-wash and toothbrush manufacturers are using tons of paper, gallons of ink and nationwide radio broadcasts to sell the public their products and, incidentally, to preach the doctrine of prevention. Fortunately, with the exception of a few manufacturers who garbled facts, some who used the fear appeal and several who distorted scientific truths, the advertising has been of a high type. The fact stands that dentists and the profession of dentistry have depended on second-hand, but not second-rate, advertising to tell their story. But we still enjoy the greatest of all educational opportunities, the opportunity to tell the patient, direct, man to man, personalized, the story of dentistry.

In the presentation of the case of preventive dentistry, this personal relationship between buyer and seller is of fundamental importance. In general advertising, which is directed toward thousands of people, the appeal must be general or abstract; in the relationship between dentist and patient, we may educate the patient to a general or abstract idea, the idea of prevention, and then personalize the idea to make it specific and concrete —the application of the idea of prevention to the individual case. Because the terms "selling," which suggests commercialism, and "propaganda," which suggests the unpleasantness of the late war, are opprobrious to most dentists, we may call this appealing to and teaching the patient education. And like all manner

and kinds of education, there are tuition fees required.

When we instruct the patient in the technic of proper brushing of the teeth, in the use of dental floss, in the requirements of the safe and sane dentifrice, in the essentials of dietetics, we are teachers of physiology. If we are to prepare ourselves to be good teachers, we must read and study and attend society meetings, all of which takes time, effort and money. Furthermore, if we are to be good teachers, we must be patient, take time and be repetitious in the presentation of our subject. If we are to be vigorous, convincing, interesting in the presentation of the subject of prevention, the patient is going to profit. And shouldn't we? I should suggest for those who consider it too much of an innovation to set down a separate fee for advice, consultation and education that they make sufficient provision in their estimates to cover the time spent in patient-teaching. If the roentgenographic, prophylactic, operative and prosthetic fee for a given case is, say, $100, I should put down an additional $5 or $10 to cover the tuition fee for the dental education of the patient.

The technical aspect of the prevention of the complications from caries may be divided into the roentgenographic and the operative. The use of bite-wing films at frequent intervals for every case to discover the beginning of proximal caries is very important. The early opening and filling of the occlusal fissures in molars after the manner of prophylactic odontotomy, as described by Hyatt, is an excellent procedure. Thorough and careful prophylactic treatment to remove plaques and deposits is an operative procedure of first importance. The early recognition of caries, the proper surgery of cavity preparation and the placement of mechanically and scientifically sound restorations represent the dentist's effort to prevent the vicious sequelae of dental caries: pulp involvement, periapical disease and systemic complications. The time and effort will be mutually profitable which we spend in explaining to patients the advantage of correct roentgenographic examinations over guesswork in the search for incipient caries; of prophylactic odontotomy over the severe excavations necessary in advance caries; of the value of prophylactic treatment over "teeth cleaning"; of the proper surgery of cavity preparation with extension for prevention, etc., over "drilling a hole"; of restorations of proper contour, contact and occlusal form over fillings or metal slugs.

PERIODONTAL DISEASE

In the consideration of the prevention of periodontal disease, we must remember that the clinical manifestations of this condition are varied and of apparently many different sources. We observe the periodontitis of mechanical origin, the perverted mechanics of occlusion; periodontal irritation from improper dental restorations, open contacts, etc.; marginal irritation from calcarious deposits; the improper use of tooth picks, toothbrushes, etc. We further observe the periodontal disease of bacterial origin: the residual infection of the periodontium as a result of such an active condition as Vincent's infection; the soft tissue irritation that comes from habitual unacquaintance with the toothbrush. Among the periodontal disease of general, systemic or biochemical origin, we find the periodontitis of diabetes and of the deficiency diseases.

Therefore, when we think in terms of the prevention of periodontal disease, we must consider the mechanical, bacterial and metabolic nature of the condition. We must perform our mechanical operations of operative and prosthetic dentistry

with both a technologic and a biologic point of view. We must restore parts to form and function and avoid the lurking dangers to the supporting tissues that come from improper contour, overhanging margins and occlusal stress and strain. What we do mechanically, if done well, may prevent the coming of periodontal disease; what we do mechanically, if done poorly, may sometimes result in serious diseases of the supporting tissues. To present the picture graphically to the patient, it is perfectly proper to present the horrible exhibit of "tin can" crowns, of the roentgenographic evidence of amalgam slugs pushed with a generous thumb into the gingival tissue, of clasps that pry teeth loose by their too affectionate embrace. When the patient views this rogues' gallery of dental criminals, he will be more receptive to the idea of mechanical dentistry done with the idea of prevention; that is, he will be ready for *good* dentistry.

There is no specific bacterium that has been demonstrated as the causative agent in chronic periodontal disease. Amebas have had their day; various forms of the streptococcus have been indicted as the agent responsible for periodontal disease. Now, we hear of detoxifying the mouth bacteria and the consequent antigenic use of the bacterial cells to produce a form of immunity. In the conquest of periodontitis of suspected bacterial origin, we must follow the fundamental principles of pathology rather than the enthusiasms of drug and chemical manufacturers. We should remember that "the probability of a successful infection varies directly with the number of organisms introduced, the virulence of the invaders and the resistance offered by the individual." Likewise, when we think in terms of the prevention of periodontitis of bacterial and metabolic origin, we must keep close to fundamental biologic conceptions and shun the fallacious claims of the nostrum manufacturer. A bottle of This or That or a tube of Such and Such from the corner drugstore may have a certain psychotherapeutic value, but will do little to decrease the dosage and virulence of pathogenic bacteria or increase the resistance of the host, and still remain a safe agent to the normal tissue cells. This certainly is not intended to mean that drugs have no place in the prevention or treatment of periodontal disease. Various medicaments —mild antiseptics, astringents, etc.,— have a definite place in the treatment of certain periodontal conditions.

I am attempting to say this: Patients cannot buy prevention of periodontal disease at a drug store in a glass bottle or a metal tube. They can buy prevention from dentists who apply the fundamental principles of bacteriology, pathology and surgery to each individual case by operative procedures which improve the hygiene of the mouth, through scaling and polishing of the teeth and hygienic restorative dentistry, and by instruction in the proper use of the toothbrush, soft-tissue massage and the essentials of dietetics. Again, standardized methods and proprietary products cannot prevent periodontal disturbance. Individual attention, personal case study, a consideration of the organic wholeness of the patient by the *dentist* constitute the only intelligent method of preventing periodontal disease. And so let us tell our patients.

MALIGNANCIES

Malignant neoplasms are apparently on the increase. In the prevention of cancer of the mouth and environmental tissues, the dentist can be of first importance. In an address on "Cancer as a World Problem," before the New York Academy of Medicine, Joseph Colt Bloodgood,

professor of clinical surgery of Johns Hopkins University, said:

> Practically every lesion of the mouth can be felt with the finger, seen with the eye, or photographed with the x-rays. As the cause of cancer of the mouth is due to ragged, dirty teeth, ill-fitting plates, tobacco in any form, and there is always first a non-cancerous lesion easily recognized, the dentist, when people are educated to come to him for periodic examination, should, with rare exceptions, find the local lesion in a stage in which it can be cured by the removal of the causes.

Complete and frequent examination by the dentist, education of the patient to the dangers of what lurks in unclean mouths and of improper dental appliances, a suspicion of all prolonged inflammation and lesions about the mouth—persistent "canker" sores, soreness of the tongue, leukoplakia of the soft tissues of the mouth—and the insistence on early surgery for unknown growths will do much to prevent precancerous lesions from becoming cancerous, and for those that have already undergone malignant degeneration, we, by our insistence on early treatment, may prevent metastasis and so save lives. If we are to fulfil our health obligation to the community, the dental examination must be something more than a hunt for holes and spaces, and our attitude must be different from that of the mechanic. In a biologic and biomechanical approach to our problems, we will find fulfilment, the larger life, and profit to our patients and to ourselves.

The entire case for prevention may be summarized in the words of Bloodgood, who, discussing the problems of the profession of journalism in public health work, said:

> We cannot expect much more of this profession (journalism) until the dental, medical, and nursing professions take up more seriously the ideas of preventive medicine. Then we will be in a better position to recommend to the journalists that the daily press is the best means of informing the people on rules of health, the necessity of preventive medicine; and not only of the new discoveries, but of their application.

The wages of neglect are payable in pain, in time, and in money.

An understanding of the economic advantage to the dentist that comes from the practice of preventive dentistry is contingent on the dentist's attitude toward his profession. For the man who is forever seeking the "big cases," the one who constantly talks of "big contracts" and thousand dollar reconstructions, the economic aspects of the practice of preventive dentistry may have no appeal. The "thousand dollar cases," most of us will agree, are windfalls that come once in a lifetime, if at all. Most of us must depend for our livelihood on the frequent return of patients, the ordinary and nonspectacular fees and routine dentistry. And, furthermore, few of our patients are prepared or willing to be the other party to these spectacular "thousand dollar" transactions. We have gone a long way toward economic improvement when we succeed in impressing on our patients the saving to them in time and money that comes from frequent visits to the dental office for examination, prophylaxis and the treatment or correction of simple carious defects or gingival inflammation. The steady flow of returning patients, each paying a fair fee for dental treatment, in the long run shows a more favorable business office report than the treatment of the occasional and spectacular case and the attending intervals of idleness. Children's dentistry, prophylaxis, simple operative procedures which are of the greatest value to the patient can likewise be made profitable to the dentist. The shunning of the simple things which are producible in great volume, in the fruitless search for the

will-o'-the-wisp of a spectacular and high fee case, is a common dental economic fallacy.

America is an insurance-minded nation. We insure our lives, our incomes against the inroads of ill-health and accident, our homes and our goods against fire and robbery; we insure against the liability of an automobile accident, a misplaced golf shot and a suit for malpractice. But insurance for dental health remains unknown. Men who spend freely of their money for every conceivable form of insurance still too commonly begrudge money spent to "insure" their dental mechanism. Let us present the case of preventive service to our patients as a form of insurance. The analogy is striking. The money spent each year for dentistry represents the "premium" necessary for the hazards, risks and responsibility of a particular case. And like all other forms of insurance, the rate is higher in relation to the hazards of the particular case: the person with a great susceptibility to caries, for instance, must pay a higher "premium" rate, represented in a greater yearly outlay for dentistry, than the person with greater immunity. In common with life insurance alone, dental health insurance pays a "dividend." To recover the money spent for accident, health, fire, burglary, or liability insurance, it is necessary that we suffer a loss of some kind. Not so with dental health insurance. The "dividends," which are large and generous, begin the day that the patient subscribes for preventive dental service, and they are payable, not in script, nor in stock nor in cash, but in the greatest of all mundane rewards—health.

CAST GOLD ALLOYS: THEIR PHYSICAL PROPERTIES AND DENTAL APPLICATION*

By JOHN S. SHELL, B.S., San Francisco, Calif.

THE investigation of the physical properties of gold alloys as related to their use in dentistry has opened a new era in the field of restorative dentistry. The empiric methods so long practiced by the dentist in selecting materials, and the dormant attitude of many dental manufacturers, led to so many failures in complicated restorations that operators were forced to modify their ideas in design to comply with the limitations of the materials. The past decade has seen a marked improvement in the physical properties of gold casting alloys for dental purposes, and as decided a change in the attitude of the progressive dental practitioner toward the reception of the accumulating data in the field of physical metallurgy as applied to dentistry.

The science dealing with the investigation of the internal structure of metals is of such recent development, when compared with most other fields, that it is not surprising to find its practical application to dentistry slower than that of the

*Read before the Section on Partial Dentures; Crown and Bridge at the Midwinter Clinic of the Chicago Dental Society, Feb. 3, 1931.

older sciences. The early investigators using a microscope to conduct researches on the structure of metals recorded their results in the form of photomicrographs, and the science was called "metallography." The value of physical tests in conjunction with the microscopic examination was soon recognized and, in recent years, extensive advances have been made through the roentgen-ray examination of metals. As the name "metallography" was not sufficiently inclusive to embrace all of the investigative methods, the term "physical metallurgy" has largely superseded the older name in this country. Any investigation which reveals internal conditions in metals or alloys is included in the science of physical metallurgy. It is a division of the broader science of metallurgy which is primarily interested in the extraction of metals from their ores and their application to the needs of civilization.

The physical properties of interest to the dentist are so extensive that the selection of a few for discussion must be purely arbitrary. The choice includes the mechanical properties of hardness, tensile strength, elongation, elasticity and fatigue limit. One chemical property will be considered because it has been so generally overlooked by American dentists. The effect of heat treatment and a brief discussion of the action of the fluids of the mouth on cast alloys will be included.

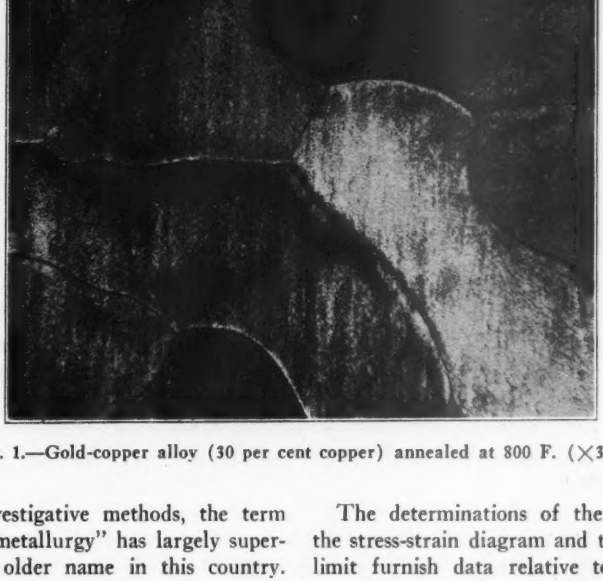

Fig. 1.—Gold-copper alloy (30 per cent copper) annealed at 800 F. (×30).

The determinations of the hardness, the stress-strain diagram and the fatigue limit furnish data relative to the mechanical properties of gold alloys that will provide a means of evaluating their usefulness for any restoration that is to be subjected to external forces. The correct interpretation of such data is not always so obvious as it may appear, mainly because of the omission of descriptive details regarding the technical procedures that

have been followed in obtaining the results.

The numerous hardness testers that may be used have led to some confusion when comparisons are being made between the various proprietary alloys, especially when charts of the physical properties are prepared by the manufacturers for the purpose of advertising their product. Such data should always be accompanied by information regarding the types of machines which have been used and a description of the dimensions and method of preparation of the test specimens.

Fig. 2.—Gold-copper-silver alloy (25 per cent copper; 3 per cent silver) annealed at 800 F. (×30.)

The hardness of dental alloys must be considered whenever the alloy is to be subjected to forces that may cause either indentation or abrasion. This applies primarily to occlusal inlays and crowns, and the hardness data should be known whenever gold alloys are to be used for such purposes. The correct hardness of an alloy for general use even in definite types of cases cannot be arbitrarily defined. The amount of occlusal force, as well as the hardness of the tooth substance, is not constant in different individuals, and the variation in the structure of the finished restoration obtained by different operators is an even more important factor to consider. An occlusal surface may be left slightly "high" or may be carved so that the force is concentrated on a small area of the alloy. A hard alloy will resist indentation and the continued impact may result in secondary disturbances. An inlay that contains no "high spots" should be sufficiently hard that it will wear away at the same rate as the tooth substance. A softer alloy will become indented when incorrectly carved and will wear down; which relieves the occlusal force so that the teeth

concerned may escape further injury. This condition is far from ideal, but is found to occur so often that it cannot be overlooked. Very soft alloys often become so badly deformed and abraded that the original anatomic form is practically obliterated. This introduces another condition which may be sufficiently detrimental to counteract all other considerations.

Hardness may be defined as "the ability to resist penetration or withstand abrasion." It can be measured in different ways, and at least four machines for testing hardness are being used for determinations on dental alloys. One manufacturer expresses this result as scratch hardness, but a larger proportion of such determinations are being made with some modification of the Brinell apparatus. This machine forces a 10 mm. ball into a specimen with 500 kg. weight. The European investigators use this machine almost exclusively for this type of testing. The Rockwell hardness tester is often used, and extensive investigation, resulting in the development of formulas and tables, makes possible a comparison between the Rockwell and the Brinell data. The Baby Brinell tester has been used by a number of manufacturers, following the choice of the Bureau of Standards, but such results are not equivalent to the value obtained from the standard Brinell apparatus and the data should not be confused.[1] A table or formula for the comparison of Baby Brinell tester results with the standard Brinell determinations would be of considerable value in comparing the European data with that obtained at the Bureau of Standards.

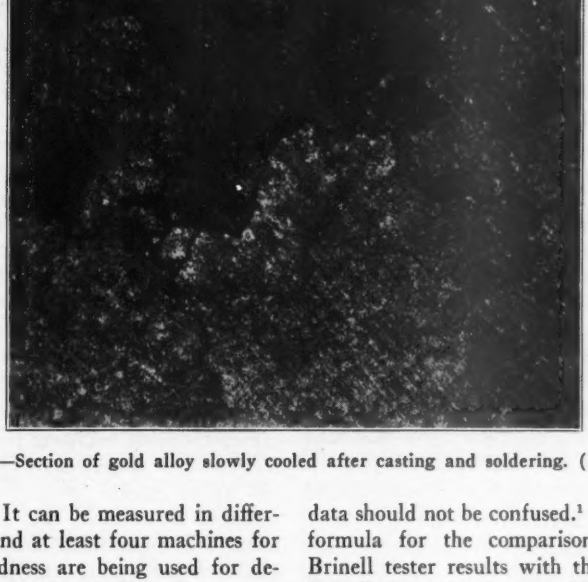

Fig. 3.—Section of gold alloy slowly cooled after casting and soldering. (×250.)

The limits of maximum hardness for alloys that are to be used in an occlusal

1. Bull. 1, Olsen Testing Machines Company, p. 24.

restoration are determined by the resistance of the tooth substance to abrasion and by the skill of the operator in reproducing the best anatomic form. The harder alloys should be used by the better operators, who are able to prepare restorations with a surface that will be found to have no points of greatest stress. A few alloys of excessive hardness have been incorrectly recommended for crowns and inlays. The alloy should wear down evenly over the opposing area and at the same rate as the enamel. In university clinics, where the operators are usually dental students, the use of softer alloys is recommended because the accumulated errors resulting from inexperience and lack of dexterity will be less serious.

The dental practitioner will obtain better results if he can intelligently interpret the data relative to the material which is being used rather than by depending on any arbitrary specification. The operator is always in the best position to make the correct decision as to the requisite hardness of an alloy for individual cases. The knowledge necessary for this decision is not extensive and with a few hours, consideration of the meaning of the data, combined with considerable clinical experience, the practitioner should be qualified to estimate the hardness value that will prove most satisfactory for each individual case.

The tensile properties, or the resistance to longitudinal forces, prove to be of the greatest importance in judging the value of cast gold alloys when they are to be used for dental restorations. The stress-strain diagram, which is obtained by measuring tension and the elongation during the longitudinal stretching of a test specimen, indicates the most important mechanical properties. From this diagram, a number of calculations can be made, which, in the English system of units, produce impressive figures representing properties such as proportional limit, ultimate strength, modulus of elasticity and elongation. Each of these determinations on gold alloys gives a direct indication of the correct use of the material, and the omission of any of this information may lead to incorrect interpretation of the remaining data.

From the breaking strength of any material, a general estimation of the other mechanical properties can be made, and when considered with the elongation of the specimen, it measures the maximum ability of the material to be cold worked. The amount of deformation by burnishing to which an inlay may be subjected is closely related to the combination of hardness and total elongation. The ultimate strength, often called the tensile strength, is usually slightly higher than the breaking strength and determines the maximum resistance of the material. The elongation between the proportional limit and the ultimate limit is a measure of the maximum amount of permanent alteration in form that can be obtained from an alloy. When it is considered with the difference in tension on the specimen between the two limits, the toughness of the material can be estimated.

Small adjustments that must be made on restorations requiring permanent deformation of the metal will be facilitated in alloys which have a considerable elongation between the proportional limit and the ultimate limit. Clasp adjustment is a typical example of the utilization of this property. The tensile tests are made by deforming the metal longitudinally, while such changes in shape may require resistance to compressional and torsional forces as well. The tests must be considered as comparative, not as absolute, measures of the amount of the adjustment that can be made.

The elongation and tensile stress up to the proportional limit indicate the force that a material exerts when slightly deformed without permanent change in shape. An alloy with little elastic elongation would be unsatisfactory if used for clasps that are to be removed occasionally, an elastic deformation being thus necessitated. The tensile stress below the proportional limit indicates the force that a clasp can exert against a tooth if it is deformed when functioning.

The springiness of alloys is closely related to the course of the stress-strain diagram below the proportional limit. This property has two attributes. The force with which a material resists deformation without permanent change in shape is commonly called "stiffness," and the amount of deformation is often referred to as "elasticity." Both of these properties are indicated by the slope of the tensile diagram within the elastic limit. A steep slope reaching high values of resistance to tensile force indicates that the wire is stiff. A flat slope with greater elongation indicates that the material can be deformed a greater distance by exerting a smaller force before permanent change in form occurs. In considering materials for a specific restoration, the operator can determine which factor in elasticity should predominate and choose the alloy which corresponds most closely to his needs. The elongation is usually measured in percentage of increase in length between two gage marks, and the tensile strength or proportional limit in pounds per square inch. For this reason, when an alloy is to be selected, the dimensions of the attachment must be considered as well as the mechanical properties.

Fatigue tests on cast gold alloys are still in the experimental stage. Alternating flexure tests have been made on a few alloys, but their application to the problems of dentistry has not been definitely clarified. These tests have relationship to the problems of dentistry but may represent a different type of determination, and the method of obtaining the values must be considered in interpreting the results. With refinements in casting technic, and the development of new alloys, the value of tests of this nature will become increasingly important. At present, their most advantageous application is in the field of wrought alloys. It may be found advisable in the future to subject certain types of cast restorations to heat treatments at definite time intervals to reduce the probability of failure from fatigue.

The method used in preparing the test specimen has a considerable influence on the data that are obtained from any particular alloy. Because of the small size of dental restorations as compared with other structural materials, it has been considered necessary to obtain test specimens of a smaller size than those customarily prepared in testing laboratories. In some cases, this reduction in dimensions of the test piece reduces the accuracy of measurements, and, in other cases, technical difficulties are involved that necessitate modification in the method of preparation that may reduce the comparative value of the smaller specimen. The simplest method of preparing ingots for testing is to pour the metal into a properly shaped mold. This method does not produce ideal specimens because segregation and other strictly metallurgic phenomena prevent the formation of reproducible samples. An ingot may be rolled, annealed and eventually worked into shape for testing. By heating to a relatively high temperature, until all the hardening caused by working has

been removed, specimens can be obtained which produce data that check closely. This method has been used by Sterner-Rainer[2] to obtain considerable information concerning gold alloys. It would seem that such results are of little value in comparing the merits of cast gold alloys, but at least data can be obtained in this manner that can be more closely duplicated than by any other method.

The obvious method for preparing test specimens of cast gold alloys is by making castings of dimensions similar to those found in practice. Unfortunately, such small specimens cannot be tested for tensile strength or elongation in the machines which are at present available. The casting must be from 2 to 8 inches in length, and longer specimens are often used. A casting of dental dimensions in diameter and 8 inches long is difficult to prepare because of the tendency toward gas absorption and premature solidification, necessitating higher casting temperature than would ordinarily be used. This is generally simplified by attaching air vents to the extreme end of the wire, but such a procedure does not correspond to the technic used in preparing dental castings. By increasing the diameter of the casting and retaining the same length, the necessity for air vents is reduced and castings can be made by a technic at least analogous to that used for dental restorations, even though the dimensions are considerably greater than will ever be found in dental practice.

It is almost impossible to obtain castings with dental gold alloys which are entirely free from imperfections, either in dental restorations or in test specimens. These imperfections in structure are often visible without the aid of the microscope and can be recognized on fracture of the metal. Microscopic flaws, usually in the form of pits, cause the greatest difficulty in the preparation of test specimens and are often responsible for the failure of dental castings. They are rendered visible by polishing the fractured section and examining it under the microscope with relatively low power magnification (from 25 to 250). Their effect on tensile strength and elongation is considerable, and any method for preparing test specimens that reduces the chances for the introduction of these flaws will produce materials of higher strength and elongation.

This is most readily accomplished by pouring the metal into an iron ingot mold and then rolling or drawing to a proper shape, following with a normalizing heat treatment that will relieve all traces of cold working. The use of a gas vent, as is customary when test specimens are cast in long wires of dental dimensions, may reduce the chances of producing flaws by allowing the gas to be removed from the mold and eliminating the possibility of its being forced into the casting. Both of these methods should give test specimens with a higher tensile value than a casting made by the customary dental methods, with the advantages of reproducibility and simplicity in favor of the worked and annealed specimens.

Because of the difficulty in arriving at any absolute value for the correct tensile properties of a dental casting, the comparative results on various alloys must be used for judging the value of any particular product. If the maximum forces on any particular part of a restoration could be determined in pounds per square inch, the proper dimension for the metal could be calculated. In such a case, the method of preparing the test

2. Sterner-Rainer, L.: Edelmetallegierungen und Amalgame in der Zahnheilkunde, Berlin: Meusser.

specimens should be as nearly identical with the dental technic as possible. The castings should be made by melting with the customary heating appliance, using a similar investment and casting with the same machine.

The data obtained from such a test specimen could be used in the calculations referred to above; and with the customary factor of safety, such a procedure should insure a satisfactory control of the design of the castings. At present, this is seldom possible, but much valuable information can be obtained concerning the failure of castings by testing specimens that have been prepared by a similar method. Test specimens that have been cast by both dentists and their technicians, as well as commercial laboratory technicians, have almost invariably been found to contain flaws. Not the least uncommon are caused by the presence of included particles of investment, gas pockets near the sprue and oxid inclusions.

The presence of microscopic pits in many castings may be due to the forcing of entrapped air into the molten gold. This may possibly help to explain the discrepancy between the contracting of gold castings as measured and the theoretical contraction as calculated from the free expansion of the alloys.

The data obtained from such test specimens are worthless, and if correct values were obtained for the alloy, such figures would not assure a dentist of a satisfactory restoration when radical flaws are so often present in the finished castings.[3]

3. The author will be glad to receive specimens of reconstruction materials which have been found unsatisfactory in practice. An attempt will be made in each case to determine the cause of the failure, and, where possible, remedies will be suggested that may prevent a repetition of similar conditions. A complete history of the case should be included.

The presence of flaws in individual castings does not detract from the value of the determinations of physical properties. It should make the dentist more cautious in condemning alloys when the fault may be beyond the control of the manufacturer. Failures of restorations can seldom be attributed to chemical composition when the proper alloys are selected, and the choice can be made only when the properties are known and correctly interpreted by the operators.

The heat treatment of gold alloys used in dentistry rests at present on a rather empiric basis. The recent work of Nowak[4] and Wise[5] indicates that many of the binary combinations of the metals so often used in dental alloys show an age-hardening phenomenon that may account for the practical results that have been obtained. The existence of hard, brittle compounds in the gold copper alloy is well confirmed, but the advisability of heat treating the materials to produce these compounds is questionable, especially if the casting has solidified with relatively large grains. The chemical compounds differ in specific volume from the solid solutions, and their formation during slow cooling sets up internal strains in the alloy that may produce fissures, usually extending along the grain boundaries.

This phenomenon occurs frequently in 18-carat gold-copper alloys (Fig. 1), and the presence of silver does not decrease this tendency to any great extent. (Fig. 2.) The presence of intercrystalline fissures has been observed in castings made from some proprietary alloys which have been heat treated. (Fig. 3.) A casting to be used in a practical case was found

4. Nowak: Ztschr. f. Metallk., 22:94, 1930.

5. Wise: Tech. Pub. 147, American Institute of Mining and Metallurgic Engineering, 1928.

to become extremely brittle after being allowed to cool slowly, and internal fissures were discovered on microscopic examination. These were probably responsible for the brittleness, since soldering increased the ease with which fractures occurred adjacent to the soldered joint.

The transformation of the gold-nickel alloys from a solid solution after annealing to a eutectic mixture during slow cooling offers an opportunity for heat treatment of alloys containing over 5 per cent of the base metal. Such combinations may produce white golds, and heat treatments that would be advisable for high copper-platinum alloys would not necessarily improve the properties of high nickel alloys. Nowak found that the physical properties of white gold-nickel alloys can be improved by carefully controlling the temperature during heat treatment. Slight variations in the time of treatment may cause a decrease in hardness and a corresponding detrimental effect on the other mechanical properties. He also observed an age-hardening phenomenon in the gold platinum and gold palladium zinc alloys, although the earlier temperature composition diagrams gave no indication of the possibility of such a result.

The problem of heat treatment for dental materials requires an extensive basic investigation, rather than the arbitrary determination of cooling rates for a certain group of alloys, and the inferred suggestion that other dental golds can be treated in the same way to obtain the best results. Dispersion hardening and age hardening are relatively new developments in metallography, and it is becoming apparent that many alloy systems that were considered inert at a temperature below the solidification range may be found highly responsive to carefully controlled heat treatment.

Most of the fundamental research on gold alloys that has proved so valuable to the dental profession has been the result of investigations that were not even remotely connected with dental influence. The dental profession should look forward to the time when the results of research on the metals and alloys which are so extensively used by them will be under the direction of men either in the profession or directly associated with it.

Even with the meager knowledge of heat treatment of dental alloys that is at present available, it is advisable to utilize this phenomenon to the greatest possible extent consistent with safety. If our attention is confined to one group of alloys so extensively used in casting saddles and clasps, especially in those cases in which no solder is to be used, the results of heating to 800 and cooling to 400 F. can be estimated with a fair degree of accuracy. This group of alloys contains about 70 per cent gold, from 4.5 to 5 per cent platinum and from 14 to 16 per cent copper, with various proportions of silver, zinc and palladium. These alloys have an ultimate strength of about 65,000 pounds per square inch and an elongation of from 5 to 15 per cent in the annealed and quenched conditions. By heating to 800 and cooling to 400 F., using various time rates, the tensile strength may be increased to 100,000 pounds per square inch or more and the elongation decreased in many cases to less than 1 per cent. By an increase in the cooling rate, the strength will not reach its maximum and the elongation will not be decreased to the minimum. An alloy with an elongation of less than 1 per cent has a tendency to fracture when deformed during the manipulation and use of a restoration including clasps or rests. The greater strength makes the use of smaller dimensions possible. These two factors must be balanced

against each other by the practitioner, and a cooling rate estimated that will produce the most desirable properties in each individual case.

The ability of the operator to prepare a well-fitting restoration and the amount of required manipulation subsequent to casting both before and after heat treating must be considered. The elongation below the proportion limit will indicate the comparative amount of deformation that can be expected without permanent change in form. This must be considered when the case includes a clasp that is to be forced around the tooth.

The construction materials for a removable restoration must have such properties as will enable the patient to place the appliance in position. This will probably require a greater amount of elastic deformation than is necessary in manipulation during its preparation. If the elastic elongation is insufficient, permanent changes in form may occur, resulting in improperly adapted restorations.

For teaching purposes in school clinics, a high elastic elongation is necessary to prevent the premature fracture of clasps during the handling of the case after casting. The student must place the restoration on the model, and if the work has not been accurate, the metal may easily be strained beyond the elongation limit, fracture resulting. As the operator becomes more proficient in designing and preparing restorations, high elongation in the heat-treated condition is not so necessary, but the absolute amount should be under the control of the person who has an intimate knowledge of the requirements of each case through contact with the patient. Such decisions cannot be left to the dental laboratory technician or to the general recommendation of the manufacturer.

The majority of gold alloys show an increase in many desirable mechanical properties as the amount of gold is decreased. If too great a proportion of base metals is added, the alloy loses its noble character and discolors when used in the mouth. In some of the very low-carat alloys, the action may become sufficient to undermine the metal entirely, causing it to become so weak that any slight strain results in fracture.

The amount of base metal which may be added before discoloration occurs has been investigated by Gustav Tammann[6] in Germany, and the reaction limits were found to occur at a definite atomic ratio of noble to base metals. (The following discussion is based on the work of Tammann as interpreted for dental alloys by Sterner-Rainer.[2])

It was discovered that no discoloration would occur if the number of atoms of gold (or the combination of acid-resisting metals) was equal to or greater than the number of atoms of base metal present in the alloy. If the atomic ratio of acid resisting metals to base metals is less than three-eighths (37.5 atomic per cent), the alloy will be completely dissolved by strong reagents, and the reaction will take place slowly in the oral fluids. The ratio of gold to copper atoms in 18-carat alloys is slightly less than four-eighths (or 50 atomic per cent), so that such a combination will discolor in the mouth. The limiting carat in gold-silver alloys is about 15.4, and for the alloys of gold, copper and silver, the limit lies between these two finenesses.

Many proprietary alloys have a composition close to this range, and some of the most popular alloys for one-piece castings contain from 50.2 to 50.6 atomic per cent of acid-resisting metal. Another

6. Tammann, G.: Textbook of Metallography (Chemical Catalog Co.), p. 305.

class of alloys that is extensively used for this same purpose contains less than 40 atomic per cent of noble metals. The operator who uses alloys of the second class with less than 50 atomic per cent of the metals gold, platinum and iridium should know that the material will discolor more or less rapidly in every mouth. The amount of palladium cannot be included in the content of acid-resisting metals, as this element is attacked by hydrochloric acid and will be slowly corroded by the oral fluids.

Alloys that have less than three-eighths atoms of acid-resisting metal should never be used for permanent restorations and are seldom advisable under any conditions. In the United States, few alloys that fall below this limit are used by the average dental practitioner, although some of the low-carat solders have approximately this atomic ratio, and the casting gold alloy mentioned above is only a few per cent above this limit.

The two limits of acid activity so extensively investigated by Tammann apply to completely homogeneous alloys. It can easily be seen that any segregation of the constituents, during either manufacture or subsequent manipulation, might result in producing a localized alloy which contained less of the acid-resisting metals. If an alloy is used whose composition is close to one of these ratios, such segregation might produce local spots that were below the limit. This portion of the restoration would become discolored or slowly disintegrated from the action of the saliva, even though an analysis of the original ingots showed a sufficient content of noble metals.

The process of liquation tends to produce a segregation of the predominating metals during the solidification of dental gold alloys. This phenomenon occurs during a time when the alloy is changing from the liquid to the solid state. Alloys usually have a range of temperature during which the metal is partially solid; and as this range increases, the opportunity for segregation becomes greater. The first solid crystals which form have the greatest proportion of the predominating metal, which in this case happens to be gold. Platinum and iridium, because of their higher melting points, also tend to separate out in somewhat greater proportion in the crystals which solidify first. The remaining liquid metal is poorer in the acid-resisting elements, and as the solidification continues, the final portions to change their state may be of a much lower carat than the original molten mass.

If the necessity arises for using an alloy whose composition is only slightly above the resistance limit, two precautions may be taken to insure a restoration that will not lose its luster because of the action of the oral fluids on the region of lower fineness. Rapid cooling, through the solidification range, inhibits the liquation of alloys and also produces more homogeneous, as well as finer, grain structures. Each of these results is desirable, but the recent tendency to cast into molds at high temperatures with overheated low-fusing alloys tends to produce the opposite effect by retaining the molten metal in the liquid condition for a long time. The correct casting temperature for gold alloys has never been investigated in conjunction with the determinations of the resulting physical properties, which include measurements of hardness, tensile strength, elongation, shrinkage and, finally, homogeneity.

The second precaution that may be taken to produce a homogeneous structure consists in subjecting the casting to an annealing process at the required temperature, and for a sufficient length of

time to allow diffusion of the segregated constituents. Sterner-Rainer suggests a treatment at from 600 to 700 C. or from about 1,100 to 1,300 F. for one-half hour, to insure homogeneity in cast gold alloys. He also suggests the use of a device attached to the casting machine which permits a slow cooling of the casting in the mold through the annealing range.

In many cases, the mechanical properties required for the restoration are such that a considerable choice is possible among alloys. If this is the case, the alloy is safest which contains the greatest atomic percentage of the acid-resisting metals, gold, platinum and iridium. If the difference in atomic ratio between the various alloys is not great enough to be a deciding factor, the material with the minimum fusing range will be most desirable. The complete cooling curve is more informative on this subject than the arbitrary values so often chosen as an indication of the melting range. Different methods of selecting these points may cause a considerable variation in the resultant data.

Few representatives of dental gold manufacturers will admit that their products might discolor when placed in the mouth, and they will seldom supply the requisite data concerning their alloys to allow a calculation of the atomic ratio of the acid-resisting to the base metals. Sufficient information should be available to allow the dentist to determine the advisability of taking the necessary precautions for minimizing the possibility of harmful segregation due to liquation.

The leading dental manufacturers have shown a commendable attitude toward the members of the dental profession in placing at their disposal data on a variety of physical properties, most of which are of considerable value. Not infrequently, the manufacturer has interpreted his own data so incorrectly that the alloy is worthless for the purpose stated in the advertising material, but may be eminently suitable for some other dental use.

On one of the charts so common among gold manufacturers, a list of the alloys with some of their physical properties is presented for consideration by the dentist, and the following example is chosen as an extreme case of misinterpretation. An alloy, recommended for inlays, is stated to have a Brinell hardness of over 250, a tensile strength of about 121,000 pounds per square inch and an elongation of over 20 per cent. If such an alloy were used for an occlusal inlay, it could easily prove detrimental to the tooth concerned if a "high spot" developed on the surface. As the tooth wore down, this would eventually occur, assuming even an average life for the filling, and even though the anatomic form were perfect, the occlusal force on the surface of the metal would continue to increase.

To my knowledge, the next hardest alloy suggested by other manufacturers for inlays, has a Brinell hardness of 175, and most producers recommend an alloy of Brinell hardness of 135 or less if any burnishing is to be attempted.

The value of the data presented by the producer would be much greater if it were more nearly complete, and most progressive manufacturers are probably planning an extension of their activities in this field. The carat of each alloy is only of importance in considering the possibilities of discoloration. The economic factor is of secondary interest. The atomic ratio of acid-resisting metals to base metals is much more valuable in considering the activity of the oral fluids on the restoration. Manufacturers could make this calculation without revealing formulas, and, in conjunction with the

cooling curve from which the fusing range can be obtained, this ratio indicates the probability of liquation.

The hardness determinations are valuable as a general indication of the mechanical properties and should be made on some indentation machine rather than with a sclerometer or scleroscope, so that comparisons with other data can be made. The stress-strain diagram should be available to permit calculations of elasticity and elongation, as well as to give indications of toughness and resiliency. If the mechanical properties are determined in both the quenched and the heat-treated condition, the additional data are valuable. The method of heat treatment should be indicated, as well as a description of the method of preparing the test specimens, including their dimensions.

With such information, the dentist would soon learn to distinguish the proper alloy for any type of restoration from the list submitted by the manufacturers. Allowance should be made for the peculiarities of his own ideas of design, combined with a consideration of the individual eccentricities of the patient. The operator would not be forced to rely on incomplete information supplied by representatives of gold manufacturers, dental technicians or other dentists.

The dentist should be qualified to make the final decisions regarding the choice of all materials that are to used in the mouth.

CALCIUM PRODUCTS IN DENTISTRY*

By W. S. RICE, D.D.S., Chicago, Ill.

TO appreciate fully the importance of plaster of Paris in dentistry, it is only necessary to realize that from the taking of an impression to the production of all but the simplest type of single tooth restoration, plaster in some form or combination must be employed in practically every step of any technical procedure. Because of their properties of setting to form a solid mass on the addition of water, the low dimensional change on setting and comparatively low changes with fluctuation in temperature, together with faithful reproduction in fine detail of any surface against which they may be poured, plaster products occupy a unique position among the materials used by the profession. A vast amount of valuable time and scientific research has been devoted to the study of other materials for their application to dental laboratory procedure, but, for many purposes, no satisfactory substitute for plaster has been found.

Since the profession is so entirely dependent on these materials for the accuracy of its results in restorative work, mastery of manipulative procedures for plaster products and a thorough knowledge of the conditions governing their behavior are essential to the highest, or even merely satisfactory, attainment in

*The papers of Drs. Rice and Shell were presented as a symposium on "Cast Bridge Attachments."

*Read before the Section on Partial Denture; Crown and Bridge at the Midwinter Clinic of the Chicago Dental Society, Feb. 3, 1931.

the art of restorative dentistry. Of no less importance is the responsibility of manufacturers of dental products to maintain the highest standards of quality, uniformity and performance in these materials, as well as to supply complete physical property data and detailed instructions for obtaining best results.

There are several reasons that this one material serves so many useful purposes in dentistry and that it is such a valuable material in the dental laboratory: (1) the property of mixing with water to produce a semifluid moldable mass which can be flowed or shaped into any desired form; (2) the property of setting to a rigid cast of the body being reproduced; (3) the setting time, which can be regulated to any technical requirement regardless of time factors involved; (4) a setting expansion which can be regulated according to the purposes for which it is employed; (5) a crushing strength, which, through recent developments, can be regulated from a few hundred pounds to as high as 10,000 pounds per square inch; (6) a low thermal expansion, which shows no appreciable change in dimensions with ordinary fluctuations in temperature up to 212 F., the change being of the order of 0.0009 per cent per degree Fahrenheit, and (7) resistance to heat and steam in casting, soldering and vulcanizing processes.

An intensive educational campaign is being carried on by manufacturers of plaster products, the object being to bring to the profession a more comprehensive knowledge of these products and their properties. Such knowledge will enable the user to develop definite technics of manipulation and thereby be assured of definite results. A high percentage of complaints of reportedly defective materials are due, not to faults inherent in the product itself, but to improper storage, incorrect methods of mixing, contamination with other materials and similar conditions beyond the control of the manufacturer. It is surprising to note how flagrantly the few simple rules for the successful handling of these products are violated, and how much resentment is engendered against a perfectly innocent material as a result of such abuses.

A greater degree of accuracy and perfection is constantly being demanded of the technician. Therefore, it is essential that all types of dental plaster products conform to the most rigid specifications. Dental plasters to meet these specifications must be prepared from the purest, especially selected gypsum rock. Every step in the manufacturing process must be carefully controlled in order to assure uniformity of quality. Every batch of the final product should be carefully tested for conformity with specifications before it is permitted to leave the factory. Hermetically sealed steel containers are now being employed, as a further precaution against deterioration of the product until it reaches the consumer. The only remaining requirement for satisfactory results, that of proper manipulation, is up to the individual user.

The exacting limits for setting time, setting expansion and dimensional changes in laboratory procedures have necessitated the development of highly refined materials which require greater care in their manipulations than just ordinary plaster. The formulas are quite complicated, changing more or less frequently to keep pace with technical advancements. The mixing of one material with another, or even the mixing of different batches of the same material, may cause disastrous results.

Plaster of Paris ($CaSO_4.\frac{1}{2}H_2O$), or calcium sulphate hemihydrate as it is known technically, is made by heating

gypsum under carefully controlled temperature conditions until one and one-half molecules of water have been driven off. Heating or calcining above 350 C. removes the last half molecule of water, a soluble anhydrite which is rather unstable and has a great affinity for water resulting. It rapidly absorbs moisture from the atmosphere and is thereby converted into the hemihydrate form. Ordinary plaster, when fresh, usually contains a small percentage of this soluble anhydrite, which reverts to hemihydrate after exposure to the air for a few days. During the period of this conversion, or aging, the setting time of the products may vary by several minutes. It was previously necessary to age plaster by long storage, but modern methods of pre-aging render it more stable and less liable to change in physical properties. Setting time usually lengthens during the aging process, the extent depending on modifying materials used in compounding.

Chemically, set plaster is neutral, being neither alkaline nor acid. Plaster of Paris contains, theoretically, 6.2 per cent chemically combined water. On long exposure under conditions of high humidity, the water content may increase by as much as from 1 to 2 per cent. This water does not chemically combine with the plaster to produce set plaster, but is absorbed. Plaster should be stored in a clean, dry place, and well covered to prevent contamination and deterioration. If stored under damp conditions, plaster rapidly takes up moisture, loses strength and soon becomes unfit for use.

The properties of plaster of Paris vary widely. Its setting time, setting expansion and crushing strength cover a wide range. These properties are dependent largely on the source of material and on the method and accuracy of control in the calcination process. It is necessary, therefore, if best results are to be obtained, that care be observed in storage, cleanliness and manipulative procedures.

Recent developments in the field of calcium research have brought to light a new method of calcining gypsum which produces a material possessing many of the characteristics of ordinary plaster, but with several advantages over plaster in physical properties. It is more stable than plaster and much stronger and has a higher resistance to heat and vulcanizing conditions.

PHYSICAL PROPERTIES

The physical properties of plaster products which are capable of measurement are setting time, setting expansion, thermal expansion, vulcanizing expansion and crushing strength.

Setting Time.—The first property encountered in working these materials is the setting time. For practical purposes, this reaction is divided into two stages, initial set and final set. The initial set denotes the time in which the material is still workable, and the final set indicates the period which must elapse before the material is hard enough for use. In certain products, such as impression plaster and investments for wax expansion technics, the time of setting is very important. A stable setting time in these products is the most difficult property to control. By the addition of accelerators or retarders, any setting time may be secured, but establishing a definite setting time at the factory does not necessarily mean that this will not change, from aging, exposure to moisture or varying climatic conditions.

For this reason, a knowledge of the methods of changing setting time is very important. The first factor in the setting time is the amount of water used in

mixing. A good rule regarding varying percentages of water is "increasing the percentage of water increases the setting time, but decreases setting expansion and crushing strength." There are numerous materials which may be used to accelerate or retard the setting of calcium products. Each manufacturer has his own retarders and methods of regulating the setting time. It frequently happens that modifiers used in one material may be incompatible with those used in another. In most instances, acceleration is best obtained by the use of a potassium sulphate solution. This chemical not only gives the normal acceleration but will further act to reduce setting expansion. The use of excessive quantities of this material may result in retardation.

Another important factor in the manipulative procedures which may be made use of to regulate the setting time is spatulation. Two kinds of spatulation are generally employed, hand and mechanical. Hand spatulation for thirty seconds will result in a longer setting time by several minutes than will mechanical spatulation. The ratio is approximately 20:8. That is, a material which has a setting time of twenty minutes when hand spatulated for thirty seconds will set in eight minutes when mechanically spatulated for thirty seconds at 1,200 revolutions per minute. The time of spatulation has also an important bearing on setting. A material which has a setting time of twenty-nine minutes when spatulated for thirty seconds may be accelerated to a twelve-minute setting time by spatulation for 150 seconds. Conversely, the setting time may be lengthened by reducing the period of spatulation.

Setting Expansion.—Setting expansion is recorded as the percentage of linear length change in plaster products during the process of setting. (Volume change is three times linear length change.) This indicates the percentage of increase or decrease which may be expected in the size of impressions or models made from them. As a result of this change, the appliance constructed over a model of these materials will be a like percentage larger or smaller than the object to be duplicated or than the mouth for which it is constructed.

By the addition of certain ingredients to impression plasters, it has been possible to reduce the setting change to the very small magnitude of from 0.02 to 0.04 per cent. With a neutral (no expansion or contraction) impression plaster, no warpage would occur as a result of the confining action of a tray, and, from our present information, it would seem that this type of plaster should be employed. If an impression plaster with a normal percentage of expansion is used, the palatal portion of the impression will be raised, a model with the error of an excessively deep vault resulting. This may contribute to undue pressure in the palate.

The effect of setting expansion on the wax pattern in the casting process has been reported in a previous paper, but is repeated here because of its intimate connection with this paper. The setting expansion of investments has been measured with plaster unconfined, and the assumption has been that the benefits of this expansion are obtained in the investing process. This change is to be expected in an invested mass which is free to expand in all directions.

In a practical case, the invested mass is confined in a rigid, practically nonexpanding brass ring. In such a case as this, what would be the effect of the setting expansion? Would there be no expansion, or would the expansion press inward on the wax pattern? In order to determine this point qualitatively, a tapered brass

plug was invested inside a brass ring. When the investment had reached its initial set, the plug was removed, and the investment allowed to come to its final set. After this state was reached, with the nonexpanding ring, the hole was smaller than the plug, and the plug would go only part way into it. The experiment was repeated with a slotted ring capable of free expansion. In this case, the plug, when placed in position in the set plaster, extended through the bottom of the investment. Thus, it was demonstrated that, in the case of a nonexpanding brass ring, the expansion of the mass of investment took place in such a way as to close the hole in the center of the investment.

The investing process as it is frequently carried out in a nonexpanding ring with a uniform investing mass was shown to result in compression and elongation of the walls of the wax pattern, with an appreciable bulging at the center of the core when the thin mix is used. This bulge appeared to be negligible with the thick mix.

It was thus demonstrated that whereas, with the use of a thin mix throughout, the benefits of the setting expansion at the gingival margin are lost and the crown is slightly larger midway between the gingival and occlusal surfaces than at the gingival surface, the practice of using a thick mix in the core and at the margins of a crown pattern and a thin mix outside affords the benefits of part of the setting expansion of the investment.

Vulcanizing Expansion.—Vulcanizing expansion relates to the change which takes place in models and investing material as a result of exposure to vulcanizing conditions. This varies with the different types of materials being used. In the case of plaster free to expand, the change amounts to from 2 to 4 per cent, caused by the calcination of the plaster and coincident absorption of water. White stones are little better in this respect, showing a length change of from 2.5 to 3 per cent. Vulcanizing stones which have been compounded to correct excessive change in vulcanization show expansions ranging from 0.10 to 0.17 per cent.

In the investigation of vulcanizing change, two methods were employed. The first consisted of the construction of test specimens, approximately one-half inch square by six inches long, which were exposed on end in the vulcanizer to 320 degrees Fahrenheit for three hours. The values above recorded were obtained from these specimens.

Determination of the relative effect of protecting materials by flasks was attempted. To date, definite values have not been obtained, but indications are that two changes in the model occur. First, there is a warpage of the model, resulting in increasing the vault depth produced by setting expansion of the material used for investing the model in the flask. This, in some instances, amounted to as much as 0.5 per cent. After these measurements were made, the flasked case was packed with rubber and run through the vulcanizer. Upon removal from the vulcanizer, accurate measurements were again made and a further increase in the vault depth was noted. There was also a slight increase in the distance between tuberosities. Both of these changes, operating to increase the vault depth of models, together with the increase in this dimension produced by confining a high-setting impression material, may partially account for misfits where the denture rides in the palate.

This leads us to the conclusion that, for flasking purposes, a material having a minimum setting and vulcanizing change should be used or, as has been

recommended in the casting process, some provision, such as lining the flasks, or the use of a flask which will permit expansion without distortion, should be given consideration. Another factor in the vulcanizing process which may contribute to distortion is the fact that a flask when heated to vulcanizing temperature expands more than the flasking materials, which makes room for expansion of the material, or distortion, as the case may be.

Thermal Expansion.—Thermal expansion is recorded as the percentage of linear length change in dental materials, especially investments, caused by changes in temperature. Most calcium products expand from room temperature to about 250 F. Above this temperature, the elimination of free water and water of crystallization occurs. This loss of water is accompanied by a contraction, the magnitude of which depends on the type of material and, to a certain extent, its plaster content.

Plasters and stones show marked contraction when heated above 250 to 300 F., this contraction often amounting to a net shrinkage of from 1.5 to 2 per cent. Shrinkage is still further increased when the specimen again cools to room temperature.

Low heat (high plaster content) investments show thermal expansion characteristics very similar to those of plaster.

Recently, there has appeared in the literature reference to a new material for compounding dental investments, known as cristoballite. This material has been selected because of its high thermal expansion at comparatively low temperatures. A thermal expansion of as much as 1.25 per cent at 1,000 F. may be obtained in a properly compounded investment. A limited amount of experience with this material would indicate that there is a possibility of overexpansion instead of the underexpansion earlier experienced with other materials. In present high heat investments, we are able to obtain as much as 0.4 per cent setting expansion as well as 0.8 per cent expansion on heating to a casting temperature, from 1,200 to 1,400 F. These two expansions combined will effectively neutralize the casting shrinkage of gold in the casting process. The use of this type of investment also makes possible the casting of inlays of accurate dimensions by the old technic of investing the pattern, setting it aside until the painting investment had set and then completing the investment with a second mix, provided a casting temperature of red heat (1,300 F.) is used. In partial and full denture casting with this new type of investment, it has been necessary to issue cautions against the use of too high burnout temperatures, because of the danger of overexpansion. This danger is particularly prevalent in technics employing master models.

In using calcium products, there are certain precautions that the dentist and the technician must observe if they wish to obtain the best results.

1. The products should be stored in a dry place.

2. Containers must be kept closed when not in use to prevent undue exposure to air. Exposure for a long time will result in deterioration, with consequent changes in physical properties.

3. If water is accidentally splashed or spilled in dry plaster, all wet material and surrounding plaster should be removed immediately and discarded.

4. Such materials as investments, stones and similar products composed of mixtures of plaster and other ingredients should be remixed dry in the container before used. While they are thoroughly mixed when packaged, there is a tendency

to segregation during shipment. Also, the top layer of dry material may be affected by long storage.

5. Careful control of the plaster-water ratio for any given plaster product assures uniformity of set, of strength and of expansion.

6. In mixing, the plaster is sifted into water, allowed to soak for a few seconds and spatulated thoroughly. Mechanical spatulation, hand spatulation on a vibrator and the ordinary method of hand spatulation are effective, and are recommended in the order named.

7. Impressions must be thoroughly soaked to prevent soft surfaces on models caused by absorption of water from the newly mixed material.

8. A lacquer type separator should be employed. Soap and other soluble separators do not produce the best surfaces on models and may affect the properties of model materials.

9. The use of a mechanical vibrator in pouring plaster materials is recommended to assure smooth, bubble-free surfaces.

10. Different plaster materials should not be mixed, as one product may contain ingredients which will destroy the setting properties of the other. Formulas are occasionally changed for improvement of products, and mixing different batches of the material may cause trouble.

WHAT FACTORS DETERMINE THE EARLY STAGE OF PARADENTOSIS (PYORRHEA)?*

By HERMANN BECKS, M.D., D.D.S., San Francisco, Calif.

CLINICAL and laboratory experience of the last few years has seemed to confirm the supposition of dental practitioners that a constitutional or internal factor is involved in many of the cases of so-called pyorrhea (paradentosis). There has been little scientific foundation for this theory up to the present time, and we are only very slowly gaining an insight into the etiology and pathogenesis of this disease.

Clinical observation does not advance us very rapidly, and a deeper knowledge of the whole organism is necessary in order to disclose the relationship between manifestations of paradental lesions and the organism on the one side, and any constitutional anomalies on the other.

My discussion will be based upon some recent publications in this field by the *Arbeitsgemeinschaft für Paradentoseforschung* (Paradentosis Research Group) and some of those who are following their lead, as well as upon my own observations. I was a member of this group before I came to America, and, since that time, a reciprocal relationship has been established with my laboratory in San Francisco, which forms the only connecting link with this work in the United States. Our group is following the lead of all of the other laboratories of the European Paradentosis Research Group and works in close collaboration with intern-

*Read before the Section on Biologic Sciences and Research at the Midwinter Clinic of the Chicago Dental Society, Feb. 3, 1931.

ists on the relationship between the behavior of the paradental tissue and that of the whole organism, which includes not only the local but the general constitutional factor as well.

In order to understand clinically this disease of the paradentium and to comprehend the effect of prophylactic and therapeutic measures, it is of major importance to distinguish between marginal paradentitis or "gingival catarrh" and genuine paradentosis. One is a disease which originates in the gum tissue in the form of a gingivitis; the other originates in the bony alveolus, perhaps in the form of an osteopathy. A differentiation between these main groups is often possible, based upon their constitutional foundation and the parallel morphologic and pathophysiologic characteristics (Boenheim, Chaim, Citron, Loos, Herz, Reinmöller).

Several years ago, Loos called our attention to a certain capillary condition which creates a predisposition to paradentosis and which points to an inflammatory genesis. If we accept the possible development of a paradentosis from a marginal inflammation, i.e., from a catarrh, it does not imply that *all* cases of gingivitis become paradentosis. On the contrary, we recognize as paradentosis only those cases in which the gingivitis is accompanied by a general physical disturbance which predisposes the individual to this disease (Loos).

In the February number of THE JOURNAL, I reported, in collaboration with Weber, the experimental production of a primary atrophic (osteopathic) paradentosis in dogs, which expresses itself in a type of horizontal and vertical atrophy. This is the first time that this form of paradentosis has been produced experimentally by diet. Practical experience has taught us that few cases of paradentosis have a true atrophic character, and we know that those forms which we produced in dogs (osteodystrophia fibrosa) are rarely found in human beings. Clinically, it is sometimes difficult to draw a sharp line between the inflammatory type and the primary atrophic (noninflammatory) type, because the inflammatory and the atrophic components often overlap.

We see, therefore, that the true pathogenic, clinical classification of paradentosis alone cannot serve as a criterion of the disease, but it should be compared with a classification based on its probable etiology. In such a classification, the disposition and constitution must be especially considered in the development of this disease picture. There has been a great deal of discussion concerning these two very essential factors, but their application to our research in dentistry has not been made.

DISPOSITION

There has been an attempt to implicate certain local causes in the development of paradentosis. Doubtless, local conditions do play an important rôle. In many cases, they are the major cause. Local conditions include malocclusion, as well as the Karoly effect, the presence of calculus or overhanging fillings and infection; general conditions, injury of the gum tissue produced by occupational diseases such as metallic poisoning by lead, mercury, bismuth, gold and copper, and secondary infection or injury of the gum tissue by scurvy or other hemorrhagic diathesis, as well as hematogenous infection. Almost every practitioner will admit that these dispositional or constitutional and more or less exogenous factors do not suffice in the majority of cases to explain the manifestation of "paradentosis," as denoted by Weski.

It might be advisable here to explain more thoroughly the term, "paradentosis," which is now generally used in Europe. "Para" means around and "dens," tooth, and "osis" expresses more or less a constitutional, trophoneurotic or even functional disturbance; in other words, chronic pathologic processess around the tooth. It is my opinion that old terms should be replaced by new only when the new are recognized as definitely better than those in use. I might emphasize that none of the terms, "periodontoclasia," "alveolar atrophy," "filth pyorrhea" (Gottlieb) and "marginal paradentitis" (Häupl, Lang) adequately express the true conditions in this disease. At the last annual meeting of the American Dental Association, in Denver, it was shown, especially in the Section on Periodontia, that more than ten different terms are used to describe pyorrhea. It is to be hoped that on the occasion of the meeting of the Eighth International Dental Congress, in August, 1931, to be held in Paris, the conference on the special question of nomenclature which has been planned will arrive at a definite conclusion as to the proper term to be used for pyorrhea. In the announcement of the title for this paper, as well as in all my publications, I have used the term, "paradentosis" because I believe it is the best term that has yet been suggested.

CONSTITUTION

From a constitutional point of view, we find the striking fact that paradentosis occurs in families, and this hereditary predisposition has been followed from generation to generation. Furthermore, it has been known for a long time that so-called alveolar pyorrhea frequently is found in association with diabetes and true gout. In gout, we are apparently dealing with a deposition of urates in the alveolar bone. After resorption of the uric acid, lacunae appear in the bone, causing the appearance of the bone structure to be changed so that the mechanical act of mastication, especially when there is abnormal occlusion, leads to a loosening of the tooth in the bony alveolus. In cases of diabetes and gout, even the most careful work on the part of the dentist is doomed to failure. Such cases indicate that metabolic disturbances have a causative relationship to the manifestations of paradentosis and should be treated primarily by an internist.

I would go even one step farther and state that, in my opinion, every case of unquestioned paradentosis diagnosed clinically should be referred to an internist for a critical examination. This does not mean that the physican alone is in a position to treat cases of paradentosis; rather, as it is a disease of the paradentium, it should be treated by a dentist. The part to be played by the physician is to diagnose and treat the underlying disease and, if possible, to influence the constitutional basis.

The systemic examination by an internist of cases of paradentosis in the last few years has disclosed the existence of interesting relations to the general metabolism: Citron (1928) reports on the pathologic changes of the vegetative system, in the sense of F. Kraus' reports, and those of S. G. Zondeck, and also on endocrine or other metabolic disturbances in paradentosis. A large percentage of his cases showing endocrine disturbances belonged to the pseudobasedow type. The examination of the blood serum of these patients showed that the calcium values were relatively high. The potassium: calcium ratio, therefore, is very low. The normal ratio potassium: calcium lies between 1.6 and 2.0, if we consider from 18 to 20 mg. per hun-

dred cubic centimeters the average value for potassium and from 10 to 11 mg. per hundred cubic centimeters the average for calcium.

Control examinations in cases of exophthalmic goiter, i. e., those with a fully developed Basedow syndrome but without paradentosis, generally revealed normal potassium values. In patients of the vegetative type who have severe inflammatory changes around the apices of several teeth, Citron found similar metabolic deviations from the normal. He offers two possible explanations for his findings: (1) that at the time of the examination, the amount of calcium in the bloodstream was being augmented by a pathologic mobilization of calcium from the tissue; or (2) that there was a primary endocrine disturbance present.

On the basis of extensive experimental evidence, we know today that calcium metabolism is governed by the parathyroid. The introduction of parathyroid extract, synthetically produced, into experimental animals has shown that in blood serum the potassium content decreases and the calcium content increases, the picture which Citron was the first to describe as the "pseudobasedow" type of paradentosis.

In cases of potassium-calcium imbalance, we must consider the hyperfunction of the thyroid as well as pituitary function in addition to that of the parathyroid. Since a close relationship probably exists between all the ductless glands, it would not be surprising if overfunction or underfunction of any one of them might cause a disturbance in their correlation which could result in the characteristic picture of a paradentosis. It therefore appears evident that a check of the endocrine activity in our patients with paradentosis is of the utmost importance to the dentist.

The number of women suffering from paradentosis is much greater than that of men. Chaim has spoken of an "ovarian spastic type" and Boenheim reports cases of changed function of the ovaries in paradentosis, which showed astonishing improvement after ovarian treatment. The changes in the activity of the generative glands are almost always hypofunctional. Citron offers the hypothesis that the exfoliation of the teeth in advanced age is due to the cessation of glandular function.

Weinmann (1928) reports a study of the metabolism in cases of diffuse atrophy of the alveolar process (Gottlieb). He studied the basal metabolism and the specific dynamic action of proteins in eighty-one patients and found that, with normal metabolism in most of the cases (90 per cent), the specific dynamic action was decreased. Weinmann concludes from his findings that this is due to a change in function of the pituitary, i.e., a constitutional disturbance of the internal secretions. These findings were discussed thoroughly by Boenheim and Citron and clarified by their own studies. They stated that disturbance of almost all of the ductless glands is to be found in

TABLE I.—ENDOCRINE DISTURBANCES OCCURRING IN SEVENTY-SIX CASES OF PARADENTOSIS.

	Number of Cases	Percentage of Cases with Endocrine Disturbances	Percentage of Total Cases Examined
Parathyroid	1	2.30	1.3
Pseudobasedow	1	2.30	1.3
Testes	1	2.30	1.3
Suprarenals	2	4.65	2.6
Ovaries	2	4.65	2.6
Pluriglandular	4	9.30	5.2
Hypofunction of thyroid	6	14.00	7.8
Hyperfunction of thyroid	10	23.00	13.0
Hypophysis	16	27.00	21.0

paradentosis. In seventy-six cases of paradentosis, endocrine disturbances were found forty-three times. The results of the examinations of forty-three cases as tabulated by Boenheim are presented in Table I.

Reinmöller, Jr., also reports twenty-five cases with disturbances of the glands of internal secretion. In six cases, the thymus was involved; in seven, the generative glands; in eight, the generative glands and the thymus, and in four, the thyroid and pancreas. From all of these examinations, it is evident that, in a large number of cases of the disease, here known as periodontoclasia (paradentosis), we are dealing with disturbances of the regulatory system of the metabolism, the ductless glands.

While it is admitted that the number of cases examined is still too small to permit us to draw absolute conclusions, undoubtedly the time is rapidly approaching when those practitioners and research workers who cling to the obsolete theory that paradentosis or pyorrhea is a purely local disease of the oral tissue, caused by bacteria, will be obliged to remodel their ideas.

My observations on cases of paradentosis made during the past few years may be mentioned here. When Gottlieb, in 1921, described for the first time the clinical picture of diffuse atrophy of the alveolar process, I was engaged in extensive microchemical analysis of the mixed and separated saliva (parotid and submaxillary). The extreme difficulties which were encountered in the study of the etiologic factor in this new disease picture induced me to examine the saliva of patients with diffuse atrophy. I hoped to find by this means a disturbance in the mineral metabolism which might be expressed in the composition of the mixed saliva. In looking over the literature, I found that normal values of the inorganic constituents of the saliva had not been established on account of the manifold influences on the secretion process. For this reason, I worked out an exact technic for microanalysis of the saliva and determined first the normal values on a large number of individuals (144) with absolutely intact teeth and normal gum tissue, i.e., without inflammation, and who were known not to have been ill during the preceding three or four years.

The analysis of the mixed saliva of patients with diffuse atrophy showed a distinct deviation from the normal. These values have been tabulated for purposes of comparison in Table 2.[1]

TABLE 2.—ELECTROLYTIC COMPOSITION OF MIXED SALIVA IN "DIFFUSE ATROPHY"

	Normal Standard Values Per Cent	Diffuse Atrophy Per Cent
Calcium	12.13	8.44
Potassium	55.89	63.56
Sodium	69.88	96.26
Magnesium	1.29	0.74
Chlorin	74.68	79.23
Phosphate	13.6	10.15
Sulphocyanate	30.9	32.19
Bicarbonate	93.16	77.97
p_H	7.153	7.08

From this table, it can be seen that, in certain forms of paradentosis, the composition of the mixed saliva reveals a marked increase of the cations over the values established for the individuals with

1. Further details concerning this examination must be omitted here. They have been published in the Proceedings of the Society of Biology and Medicine, 1928, Vol. 26 pp. 93-95; Ergebnisse neuerer Speicheluntersuchungen mit besonderer Berücksichtigung der Gravidität und der Paradentosen (Monograph), Berlin: Hermann Meusser; General Aspects in Pyorrhea Research, Pacific Dent. Gaz., 37:259 (May) 1929.

mouths free from pyorrhea. In particular, the amounts of potassium and sodium are higher, while, correspondingly, the other values have decreased. The calcium and phosphate are reduced approximately 25 per cent and the magnesium even 40 per cent. The number of cases analyzed is still very small.

This fundamental change of the electrolytic content of the mixed saliva in comparison to the normal values indicates a generalized metabolic disturbance. A specific relationship to any of the organs or to the endocrine or vegetative system cannot be seen from these results. For this reason, in the last two years, these examinations were continued and extended to a general physical examination of the patients, including the organs and blood, as well as a determination of the basal metabolism. The exact plan which was followed during these examinations is to be found elsewhere.[2]

Our cases included not only those presenting diffuse atrophy but also all cases of paradentosis, since methods of demonstration and deduction in research are without value when they adopt *a priori* a definite clinical, an etiologic or a pathologic-anatomic foundation (Loos). Material is collected very slowly because the evaluation of the results is only possible when it is carefully selected and the examination is absolutely complete. The comparative values of blood and saliva show interesting results, and a final report on this work will be rendered in June of this year.

I may state now that, in a large percentage of the cases under my observation, we are dealing with disturbances of calcium metabolism, which is regulated by the endocrine system. The calcium values of the blood for the most part are very high, confirming the findings of Citron; while the calcium values of the saliva are below normal. Most of the basal rate values lie on the negative side and offer interesting possibilities for comparison with the changes in the mineral metabolism.

The potassium findings of the blood serum and also those of the saliva are strikingly increased in a large percentage of cases. I have mentioned this increased amount of potassium in the saliva earlier in this paper in connection with the examination of cases of diffuse atrophy. These findings may prove to be of special importance for the recognition of a special type of paradentosis established by Spiro, Loos and Herz on the ground of an arthritic allergic diathesis.

A brief discussion of this disease picture follows. According to Paul Spiro, we understand by arthritism or the arthritic diathesis a special constitutional disposition to a number of distinct diseases; in childhood, to the manifestation of exudative diathesis, and during and following adolescence, to certain neuroses, especially vegetative neuroses. In the latter category, we might mention bronchial asthma, mucous enteritis, urticaria, migraine and certain forms of epilepsy, and also manifestations of the rheumatic and rheumatic-arthritic diseases. Furthermore, we may include a triad of metabolic disturbances, namely, gout, obesity and diabetes, and last, and perhaps the most frequent manifestation of arthritism, arteriosclerosis.

Among the pathomorphologic and pathophysiologic findings in these diseases, Spiro emphasizes particularly the following: an increase in the number of eosinophilic leukocytes and in the amount of potassium in the blood serum and also an increased vasolability, especially of the smallest capillaries.

2. Footnote 1, last reference.

In considering the findings in the examination of patients suffering from paradentosis, an increase in the number of eosinophils has already been described by Chaim. This I have confirmed in a limited number of cases. In 60 per cent of the cases examined by Herz, in addition to the excessive number of eosinophils, an increased amount of potassium was also found, which means, according to Spiro and Herz, that certain cases of paradentosis should be placed in the group under arthritic diathesis.

In classifying clinicomorphologically the material of Herz, the striking fact appears to be that all cases showing an increased amount of potassium or an excessive number of eosinophils, or both, disclose a distinct horizontal atrophy of the alveolar process. The clinical analysis of this type of paradentosis is, therefore, described as follows: primary catarrhal gingivitis with consecutive osteitis and horizontal atrophy; to which may be added arthritic manifestations: an increase in the amount of potassium in the blood serum and in the number of eosinophilic leukocytes, or both.

When a definite endocrine disturbance accompanies an arthritic disease, endocrine therapy is often beneficial. In cases in which an endocrine disturbance cannot be found, according to Spiro, the abnormal potassium: calcium ratio may be restored by the administration of calcium (calcium gluconate). The dietetic treatment of arthritic diseases has frequently proved successful, i.e., a diet poor in meat and eggs and rich in fruits and vegetables.

In this connection, I wish to take a definite stand against the conception of pocket formation held by the Vienna school. This problem is of the greatest importance in the study of the morphologic aspect of paradentosis and the question as to what conditions determine the formation of pockets in the early stage of paradentosis which might show pus discharge later on. Kronfeld, who represents the theories of the Vienna School in this country, in a recent article on the epithelial attachment and so-called Nasmyth's membrane discusses my interpretation of pocket formation. On the basis of Gottlieb's interpretation of the detachment from the tooth surface by a simple loosening, that is, by a separation of the deeper layer of the enamel epithelium from the cuticula dentis or from the enamel itself, he criticized my conception adversely, but without discussing his theory.

Considering the extreme importance of a final agreement as to this question, it would have been better if the changes in the region of the epithelial attachment which I first described had been freely compared with those shown in his material, as this would have offered an opportunity for the reader of this article to form his own opinion as to why I believe that only the movement of the bottom of the pocket down to the cemento-enamel junction is a normal physiologic process. Additional proof of my contention will appear in the March issue of *Paradentium,* the organ of the *Arbeitsgemeinschaft für Paradentoseforschung,* in Berlin.

In my first paper on this subject, I proved that the simple loosening of the enamel epithelium from the tooth surface during tooth eruption and pocket formation (Gottlieb's theory) does not exist. but the movement of the bottom of the pocket toward the apex after the tooth has reached the occlusal line is due to the progressive degeneration of the enamel epithelium. The mouth epithelium follows by proliferation in order to cover the defect. This is accompanied by a slow atrophy. The pocket is bordered on one

side by the tooth surface or cuticula dentis and on the other by the mouth epithelium. My findings have been confirmed without reserve in the molars of rats, in an article published by Skillen, which is excellently illustrated. Gottlieb, in a recent article,[3] seems to recognize the probability of the accuracy of our conclusions and offers another explanation of these changes, also observed by him, which is unsupported by any evidence.

When the degeneration of the enamel epithelium is complete, the bottom of the pocket has reached the cemento-enamel junction. Before this point is reached, the remnants of the enamel epithelium have already proliferated along the cementum. This new epithelial bud is looked on by Gottlieb and his pupils as a part of the normal physiologic eruption of the root which proceeds toward the apex with increasing age. The rate of speed varies with the individual. The bottom of the pocket follows step by step and does not remain at the cemento-enamel junction any longer than at any other point on the tooth surface. In contrast to Gottlieb, I have called this new epithelial bud which is formed only after the bottom of the pocket has reached a certain point distant from the cemento-enamel junction, a protective measure of the organism. If this bud had not been formed, theoretically we would have a point of attachment at the cemento-enamel junction after complete degeneration of the enamel epithelium. This has never been observed histologically. I believe this new bud is much more vital and resistant than embryonic enamel epithelium, which has fulfilled its function and therefore degenerates slowly.

Since the mouth epithelium proliferates only toward the apex behind the enamel epithelium in order to cover the threatening defect, the movement of the bottom of the pocket must stop at the cemento-enamel junction. I have stated that, in all cases of which I have made histologic examination, when the bottom of the pocket has passed the cemento-enamel junction, pathologic process was present.

Kronfeld states in his article that I have not shown a "single slide" which demonstrates the location of the bottom of the pocket exactly at the cemento-enamel junction, and that "never among the innumerable human and animal teeth sectioned has there been found one in which the bottom of the crevice ran all around the cemento-enamel junction." That there is a condition in which the bottom of the pocket is to be found exactly at the cemento-enamel junction should be obvious to Kronfeld as well as it is to me. Pictures illustrating this condition have appeared many times in the literature. It is, therefore, not essential that I add another confirmatory picture. The only question which arises is whether, at the cemento-enamel junction, the morphologic conditions of the relations between the mouth and the enamel epithelium are exactly the same as above at the surface of the crown. Under entirely normal conditions, i.e., without any inflammation either recent or present at the time of the death of the individual, this is true. No pictures have been published in the literature at any time which would indicate the contrary.

May I emphasize that I never expect to find the bottom of the pocket at the cemento-enamel junction on the entire circumference of the tooth. Kronfeld stated that "the rate of detachment and downward growth of the epithelial attachment is never uniform around the whole circumference of the tooth" and I

3. Gottlieb, Bernhard: Fortschr. d. Zahnheilk., No. 5, 1930.

wish to add to this statement that this is due to the manifold influences which affect in varying degree the free margin of the gum and the bottom of the pocket on all sides of the tooth.

The movement of the pocket toward the apex, which is due to the degeneration of the enamel epithelium, must, therefore, occur more rapidly on one side of the tooth than on the other. This does not prove that the bottom of the pocket under normal conditions simply passes over the cemento-enamel junction to the surface of the root without any exogenous or endogenous influences.

The next question which should be considered is: Within what age limits does the enamel epithelium degenerate downward toward the cemento-enamel junction?

There are a large number of cases described in the literature in which the bottom of the pocket is still situated in the region of the crown at an advanced age, and recently I had the opportunity to examine a number of human jaws which confirmed these findings. We, therefore, must conclude that, under normal conditions, the degeneration of the enamel epithelium occurs very slowly, and the bottom of the pocket reaches the cemento-enamel junction only at an advanced age. When any pathologic process occurs in the region of the epithelial attachment or the old enamel epithelium degenerates with increased speed, due, in general, to a disease of the entire organism or on the basis of a constitutional disposition, the bottom of the pocket may reach the cemento-enamel junction early in life and even may proceed to the surface of the root. It is rare to find a case in a person younger than 20 years in whom the cemento-enamel junction has been reached. On the other hand, no absolute statement can be made concerning the age at which the bottom of the pocket will reach the cemento-enamel junction.

Another interesting observation is that in all cases at my disposal in which the bottom of the pocket is located exactly at the cemento-enamel junction, an inflammation or some pathologic process had already occurred. This fact may also explain why the bottom of the pocket is never to be found at the cemento-enamel junction continuously around the entire circumference of the tooth.

As long as Gottlieb, Orban and Kronfeld do not differentiate between the mouth epithelium and enamel epithelium in the region of the epithelial attachment, it is useless to continue the discussion of the question of detachment because the morphologic picture of detachment as described by Gottlieb and advocated by Kronfeld in this country are refuted by my publications.

CONCLUSIONS

1. The bottom of the pocket will always be found at the point where the mouth epithelium joins the degenerating enamel epithelium. Parts of the enamel epithelium may still be connected with the tooth surface.

2. A continuation of the hornified surface of the mouth epithelium over the tooth surface as described by Gottlieb does not exist. There is an interruption at the bottom of the pocket caused by degeneration of the enamel epithelium, and this area represents a *locus minoris resistentiae* for infection.

3. A simple loosening of the enamel epithelium from the surface of the tooth during its eruption, as well as the pocket formation, as described by Gottlieb, does not exist.

4. The movement of the bottom of the pocket toward the apex is determined by the progressive degeneration of the

enamel epithelium. The pocket formation is due to a separation of the surface of the mouth epithelium from the basal layer of the degenerating enamel epithelium.

5. Under normal conditions, the bottom of the pocket is always to be found on the surface of the crown. A definite statement cannot be made as to the age at which the degeneration of the enamel epithelium is completed. The slower the degeneration of the enamel epithelium, the more favorable the conditions for the tooth.

6. When the bottom of the pocket has reached the cemento-enamel junction or has passed it, in all cases which have been observed up to the present time, a pathologic process is responsible; either an inflammation or a disease of the whole organism or even a constitutional factor.

These degenerative changes, as described, in the region of the epithelial attachment play an extremely important rôle in the pathogenesis of paradentosis.

In the discussion of the constitutional and internal factors which doubtless, according to current belief, determine to a significant extent the development of paradentosis, it can be noticed that our pathogenic and etiologic assumptions are as yet not wholly substantiated. Only through intensive work along the lines suggested by the questions brought up will we succeed in the course of time in establishing certain uniform etiologic-pathogenic clinical types of paradentosis which will be readily recognized by both the dental and the medical practitioner. Diagnosis and therapeutic measures will then be more successful than at the present time.

DANGERS OF OPERATIVE OR SURGICAL WORK IN PRESENCE OF VINCENT'S INFECTION

By FRANCIS H. DALEY, D.M.D., Boston, Mass.

IN any case of acute Vincent's infection, operative or surgical work is absolutely contraindicated. It has been our experience that any such work, if done while the disease is acute in character, will predispose the patient to a further extension of the process, general as well as local. The result is usually disastrous; in a few cases, it has been fatal.

Vincent's infection is primarily a disease of the protective covering of the oral cavity—the oral mucous membrane. Needless to say, the resistance of these tissues must be lowered before the organisms of the disease attack them. If, weakened by the disease itself, they are weakened still further by mechanical or surgical manipulation, we surely cannot expect the best results in treating the disease or any coincidental condition.

Operative work, while not attended by the dangers of surgery, will nevertheless traumatize the tissues to such a degree that the course of the disease may be prolonged or the process extended into susceptible areas. The acute symptoms must be controlled before scaling and other prophylactic measures are employed.

When scaling is instituted, it should be done as gently as possible, and the areas so treated should necessarily include only a small number of teeth. As the symptoms subside, it is possible to increase the thoroughness of the prophylactic measures. Restorative work, either fixed or removable, is contraindicated while the disease is present. If such work is done before the condition is completely cleared up, it will tend to keep the tissue resistance lowered for a long period of time. It prevents complete eradication of the disease and impairs the efficiency of the restorative appliance.

If, for the relief of pain, it is absolutely necessary that operative work be done, temporary measures may be taken until the acute symptoms have disappeared and the disease is under control. The patient may complain that a carious tooth is aching, yet, in quite a few cases, we have treated the Vincent's infection without treating the tooth in question, and the symptoms have subsided.

Surgical procedure of any kind is contraindicated if Vincent's infection is present. The resistance of the patient is a difficult thing to measure, and none of us can say that one patient could stand surgical methods and that another would not be able to do so. We do not know until we have tried, and then it may be too late to reverse our judgment. I believe that carrying out a surgical operation in a mouth in an acute Vincent's infection is comparable to giving a general anesthetic during an acute pulmonary condition. The results may not be fatal, though fatalities have occurred. We can expect an extension of the Vincent's infection with a consequent delay in healing. Sloughing to a marked degree is common, following extraction or surgery, and the deeper structures involved are predisposed to streptococcus invasion with a streptococcus septicemia a possibility. The Vincent's organisms themselves do not seem to be directly involved where septicemia occurs, but they seem to predispose to the streptococcus invasion in many cases. Several cases of agranulocytic angina seem to have been directly traced to Vincent's organisms as the primary, predisposing factors.

A number of cases of pulmonary gangrene have been traced to Vincent's organisms in the mouth. Both Plaut and Vincent, as well as others, have warned against the administration of a general anesthetic with an active Vincent's infection of the oral cavity. It has been proved that organisms inspirated from the mouth have produced lung abscesses. It has also been shown that about 80 per cent of all cases of pulmonary gangrene show Vincent's organisms on smearing. In many cases, of course, they are probably secondary invaders.

The dental profession must realize that although they are dealing with a condition which is local, any procedure which tends to extend the process may, directly or indirectly, expose the patient to a series of conditions which have the possibility of a fatal termination.

416 Huntington Avenue.

THE CAST GOLD INLAY*

By E. R. HART, D.D.S., St. Louis, Mo.

I HAVE selected two decidedly important steps in cast gold inlay technic which usually are not given sufficient consideration.

In viewing the many inlays that come under my observation, I am astonished at the lack of thought given to these two steps: cavity preparation and the making of the wax patterns.

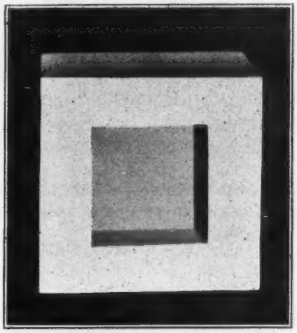

Fig. 1.—Simple mortise used by the stone mason and the wood joiner.

Of necessity, there must be a properly formed cavity; and in the preparation of this cavity, the operator should have a guiding conception of it based on fundamentals, and he should be able to read at a glance, in the wax pattern the utmost detail of the preparation.

*Read before the Section on Operative Dentistry, Materia Medica and Therapeutics at the Seventy-Second Annual Session of the American Dental Association, Denver, Colo., July 24, 1930.

We all know that, regardless of the perfection of the investing and casting technic, the omission of any detail in either cavity preparation or wax pattern technic will preclude the possibility of producing a perfect inlay. There are no miracles performed in investing and casting. A perfect wax pattern made from a poorly prepared cavity will spell failure just as surely as will a poor wax pattern made from a perfectly prepared cavity.

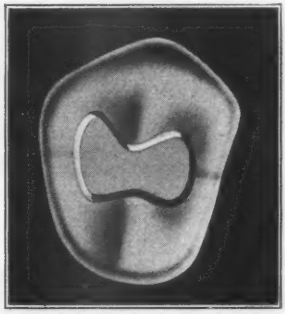

Fig. 2.—Simple mortise applied to a class 1 cavity on the occlusal surface of an upper bicuspid.

To prepare a cavity correctly, we should use, fundamentally, the earliest forms of retention known to man; the simple and compound mortise of the stone mason, the dovetail and dowel and sometimes the tongue and groove of the wood joiner, regardless of modification or elaboration.

After the completion of the cavity and prior to the making of the wax pattern, the toilet of the preparation should be given attention. We should always remember that regardless of what type of cutting instrument we use to remove carious matter, we do not sterilize as we cut, and even though our digital sense tells us we have arrived at solid tooth structure, this solid structure can be and usually is deeply impregnated with septic material. Consequently, all cavities should be sterilized, after which a coating of cavity lining should be used to seal the dentinal tubules and to protect the pulp from the irritating influence of the acid when the inlay is finally cemented. The toilet of the cavity having been observed, we now proceed with the making of the wax pattern.

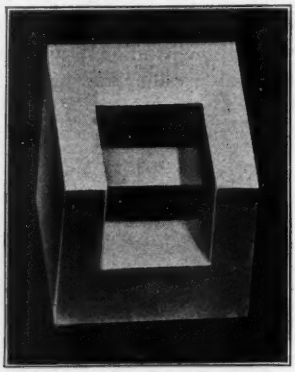

Fig. 3.—A compound mortise.

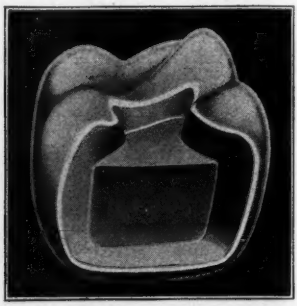

Fig. 5.—A compound mortise as applied to a class 2 cavity in an upper molar after the dovetail is added.

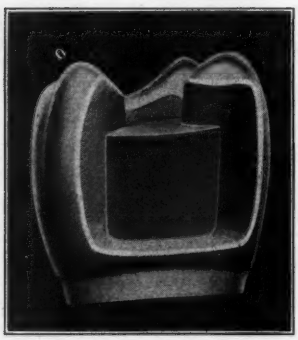

Fig. 4.—A compound mortise as applied to a class 2 cavity in an upper molar before the dovetail of the wood joiner is added.

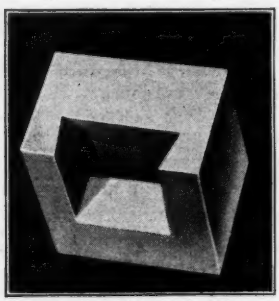

Fig. 6.—A dovetail of the wood joiner.

Granted that we have a wax suitable for the purpose of making a perfect pattern and also that we know and appreciate its physical properties, we proceed with the making of a pattern which will produce a finished inlay and one which will

be a complement to the tooth as prepared for its reception. A casting made from such a wax pattern gives us the assurance that not only will the tooth be saved from further decay on such surfaces as are involved, but also the adjacent tissues will be so protected that pathologic conditions will not be set up. If we were making an inlay the only function of which would be to seal a cavity, our work would be simple, but the resulting damage to the surrounding tissues would be most disastrous. If an inlay is lacking in any anatomic detail, not only is that tooth doomed, but the rhythmic function also of the entire masticatory organ is endangered.

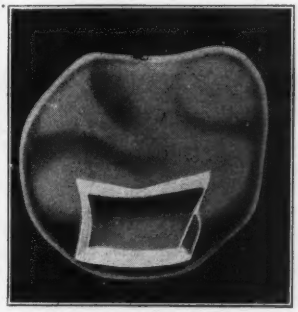

Fig. 7.—A dovetail as applied to a class 2 cavity in an upper molar.

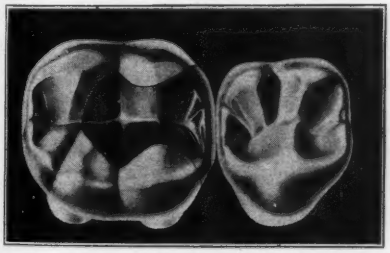

Fig. 8.—The ideal contact point as to size, shape and location, the embrasure being obtuse on the buccal aspect and acute on the lingual.

Let us now analyze the wax pattern. Whether we use the direct, indirect, direct-indirect or direct-indirect-direct technic, our desire should be to obtain in the wax pattern the following: (1) an exact copy of the interior of the cavity; (2) the location, size and shape of the approximal contact point; (3) the point or points of deepest penetration of the opposing cusp or cusps; (4) the angles of the incline planes, and (5) correctly shaped embrasures, obtuse on the buccal and acute on the lingual aspect.

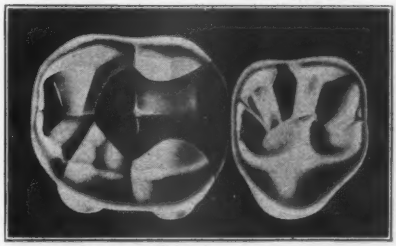

Fig. 9.—Absence of contact point. Although there is a marginal ridge, it is unbroken by sulci or spillways.

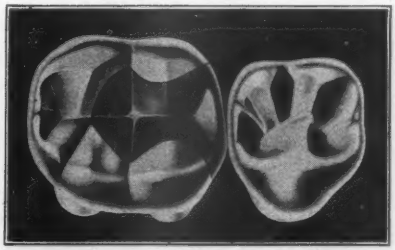

Fig. 10.—Contact point placed too far buccally.

Viewing the cavity side of a wax pattern, we should be able to see sharply defined angles formed by the walls of the cavity as they join the flat pulpal and gin-

gival seats. Should these not be faithfully reproduced, we may expect poor margins about the periphery when finishing the inlay.

Viewing the outer or approximal surface of a wax pattern, we see an indentation, which, at this time, is the lowest point in the pattern and represents the location, size and shape of the approximal contact point. This concavity becomes a convexity as the wax pattern is refined.

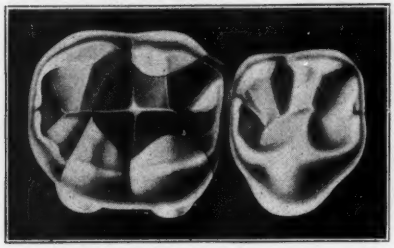

Fig. 11.—Contact point placed too far lingually.

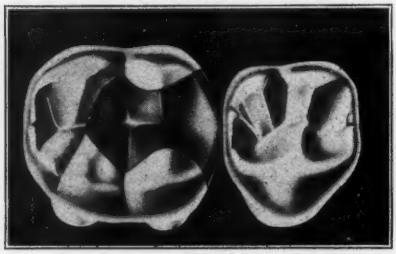

Fig. 12.—Contact point area too small, acute embrasures both buccal and lingual resulting.

By this refining of the wax pattern, we create the ideal contact area, which was determined by the approximal side of the adjacent tooth and not by some standardized or fancied shape or size.

What is the approximal contact point? Normally, it is the crest of the greatest convexity on the approximal surface of a tooth. What determines its size, shape and location?

Generally speaking, the size, shape and location are determined (1) by the approximal surface of the adjacent tooth, whether or not both teeth are in proper mesiodistal or buccal lingual alinement; (2) by the buccal-lingual, occlusal-gingival measurements; (3) in malpositioned teeth, by whatever change the operator may deem necessary for more protective

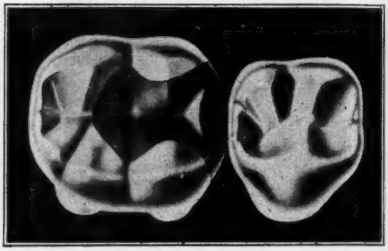

Fig. 13.—Contact point correct as to size, shape and location, but with the approximal margin of the occlusal surface showing no development of the marginal ridge and being lower than the adjacent tooth.

Fig. 14.—*A*, approximal convex contours lost owing to decay. *B*, approximal contact from occlusal to gingival aspect. *C*, approximal contact from occlusal to subgingival aspect.

embrasures; (4) by luxation, age, texture of food constituting the individual's diet, habits such as attrition during sleeping hours, and nonuse, due to lack of vigorous mastication and (5) by the combined actions of the vertical, horizontal and oc-

clusal wear, as well as approximal decay, which will cause the loss of one or both convexities, presenting approximal contact surfaces from occlusal to gingival and sometimes subgingival aspect.

Again referring to the occlusal surface of a wax pattern, whether it be a class one, two or compound second, with or without modification, we find that in normal or nearly normal cases, the wax pattern presents elevations and depressions. The elevations represent the cusps, being angular or rounded, the angles either acute or obtuse. The points of deepest penetration form the fossae, from which ramify the sulci.

The approximal margin of the occlusal surface should be so carved as to develop a ridge with its greatest plane sloping toward and ending in the center of the fossa. This, the marginal ridge, normally has two spillways. By developing in our wax pattern the marginal ridges, fossae and spillways, we make it possible to direct the food under compression bucally and lingually, thereby relieving the stress that otherwise the approximal contact would have to resist, and giving assured protection to the gingiva, which normally fills the interproximal space.

We observe in extremely abraded occlusal surfaces that the fossae and sulci are nearly obliterated and the cusps entirely so. The registration from the opposing tooth or teeth found in the wax pattern determines the only correct occlusal relationship that will function physiologically. This being true, flat occlusal surfaces and those presenting cusps should never be placed in apposition. Consequently, we must adhere to the occlusal form registered by the opposing tooth or teeth or change the vertical dimension and rebuild the entire masticatory apparatus.

506 Olive Street.

DISCUSSION

B. B. Ide, Baltimore, Md.: In the preparation of cavities for the inlay, as well as for the use of other filling materials, serious consideration should be given to the type or condition of the mouth under treatment. We are all familiar with the extremely susceptible case, with caries attacking the teeth on all surfaces not easily cleansed for foodstuffs during mastication. Aside from other means for combating decay, it is very necessary in these cases to be radical in carrying out the principle of extension for prevention. Cavities must be extended to absolutely self-cleansing areas in order to arrest the progress of caries on those surfaces involved. Dr. Black's principles of extension have been severely criticized because of too much destruction of tooth structure; but in the mouth extremely susceptible to caries, cavities cannot be extended too far externally for safety. It has been my practice for many years to regulate the degree of extension on enamel surfaces by the degree of susceptibility to tooth decay indicated in the case and I have found the results quite satisfactory. I wish to compliment Dr. Hart for his reference to the anatomic restoration of the tooth by means of the correctly shaped wax pattern. In the past, there have probably been as many teeth lost through lack of contact in poorly made fillings as have been saved, and too much emphasis cannot be placed on the importance of anatomic restoration of lost tooth structure. A study of tooth form discloses the fact that a set of human teeth in normal relationship is a beautiful and extremely efficient mechanism. Nature has produced a scientific collection of marvelously constructed units, every one of equal importance, and the loss or partial loss of one of these units disrupts the entire machine. I often wonder, do we dentists, in our daily office routine, fully realize the extreme importance of not only preserving but also restoring every tooth to its full anatomic form? Not so much for the efficiency of that one unit, but as a necessary step to insure the integrity of the masticating apparatus as an entity. We are called on to treat and fill these units so often that, I am afraid, we are naturally quite prone to forget the machine as a whole, and whenever we are emphasizing the importance of restoration to natural form and function of these units, I trust we may always fully realize that it is for the

life of the units as a whole that we are taught to restore with such minute attention to detail. In his treatment of the wax pattern, Dr. Hart has emphasized anatomic form, but has entirely ignored a successful technic in its manufacture. Among the other quite necessary steps, such as the use of a good wax, proper softening and adaptation to cavity walls, I believe the retention of the wax under pressure until it has cooled is probably the most important step in the production of a wax pattern that will insure a successful result. In this, as in all other steps in our operative procedures, there is only one royal road to success, namely, a thorough mastery of the fundamentals and minute attention to detail in every step taken in the development of every operation.

CURRENT DELUSIONS IN FULL DENTURE PROCEDURE*

By CHARLES M. McNEELY, D.D.S., Brooklyn, N. Y.

DENTURE problems are of such a general nature, and enter so thoroughly into the work of every dentist and the lives of such a large portion of the public, that discussion about them is almost universal. It naturally follows that when so much is being said about this subject, some persons are bound to make statements which are not founded on sound basic principles. It is possible to condone ridiculous suggestions that are made by patients, but when dentists who are known nationally and whose opinions are apt to be accepted as founded on a thorough study of this subject make assertions that have a tendency to place prosthetic procedure back where it was twenty-five years ago, something ought to be done about it. In the field of construction of great commercial projects, the society of engineers has laid down certain definite fundamental principles that must not be violated in construction procedure. It seems to me that the outstanding motive for the continued existence of this section is to present to the dental profession the basic fundamentals for a well constructed set of dentures. Not until dentistry, without thought of commercial gain or personal profit, develops a method whereby these fundamentals can be incorporated into a finished product will the profession be fulfilling its full duty to the public.

As a patient reaches the condition when full dentures become necessary, he makes three paramount demands, usually in the order given: esthetics; efficient function with ease and comfort, and duration of service. He will not, of course, use these words, but they express to us exactly what he will demand, whatever his words may be. Referring to the first requirement: most patients have very positive opinions. Some, who have a distorted sense of the esthetic, will want the teeth small, even, white and pretty. Such patients must be handled with considerable tact in order to give them what they should have, and make them feel that they have just what they wanted. Others, and fortunately they now constitute the majority, want something more in har-

*Read before the Section on Full Denture Prosthesis at the Seventy-Second Annual Session of the American Dental Association, Denver, Colo., July 22, 1930.

mony with good taste. But whatever the patient's opinion is, its expression will invariably be accompanied with some definite advice. Time will not permit going into this phase of the work in detail. It is merely mentioned as one of the three essentials which constitute the basis of all well constructed dentures; namely, esthetics, function and duration of service. Our profession is honored by the names of many men who have devoted their lives to developing methods and procedures which would incorporate these essentials as the ultimate of accomplishment in the finished product.

Much progress has been made during the last decade in the refinements of denture construction. In the maelstrom of effort on the part of many individuals to present something original, seemingly with no other motive than a desire to have their names on the roster of the Hall of Fame, there seems to be a grave danger of confusion to the rank and file of our profession. The result of all this confusion is, to say the least, alarming in the effect it is creating in the minds of a host of dentists who do not study this problem intently. Of course, men who have a complete understanding of the problem can separate the chaff from the wheat. But it will be most unfortunate if the pendulum starts to swing backward, and the idea establishes itself in the minds of many that all that is necessary for this work is to master a good impression technic, take a rather indifferent bite, send this to almost any dental laboratory and have a set of dentures made. This statement may sound rather academic; but think it over and judge for yourselves. One of the three essentials is function. There is not a question in the minds of most men earnestly striving to master this subject that the basic principle in construction procedure with which to obtain function is balanced occlusion. It is a sad commentary on our profession, but I believe there are thousands of dentists throughout this country who would prefer to believe balanced occlusion unnecessary, simply because it seems a little difficult to obtain. In support of this statement, let me ask you to consider how many times you hear men say that when there is a bolus of food between the teeth they are not in contact anyway, so what is the use of all this balancing business. I even heard one dentist say in a clinic given to men in general practice that balanced occlusion was injurious to the supporting tissues. Of course, it is not probable that there is anyone here who does not know of, or does not believe in, its necessity, but on the bare possibility, we will briefly go over it.

We can fairly well define balanced occlusion as such contact of the occlusal surfaces of all of the teeth as will maintain stability of the dentures in the various excursions of the mandible. Now I will concede that we are not able to maintain contact on all of the teeth in every possible mandibular movement; but this definition states the ideal, and in all our work we should at least strive for that. As to the condition existing when the bolus of food is between the teeth: of course, there is not occlusion at that time. There is not a balance then, and it is not needed. The food is a yielding mass, and the dentures rest on a yielding surface. If the teeth have been placed in proper relation to the ridges, and the adaptation of the bases to the supporting tissue is correct, they will withstand this pressure without damage. It is when the teeth pass through the food and the contact of porcelain against porcelain occurs that we want balance. It is when these unyielding surfaces meet

that the dentures tip or move about, if the teeth are not in proper occlusal relation.

In the act of incising, we protrude the lower jaw. There is some strain on the teeth when passing through the morsel of food, and some tendency for the dentures to be unseated. If, when the incisors meet, there is perfect balance on all of the teeth, the dentures will be held properly in place. If only the anterior teeth make contact at the completion of the incising stroke, the unseating is apt to be completed, and the patient must then reach about for centric position to reseat the dentures. This is, of course, presuming that they have at least been constructed in centric relation.

We are told by the periodontist that the most prevalent cause of the destruction of tissue in periodontal disease is traumatic occlusion. Surely, traumatic occlusion in dentures with the additional torsional stress that is not present in the natural dentition will cause changes in the supporting tissues. Slight interference in occlusal relationship might cause only movement enough to stimulate these supporting tissues excessively, and set up physiologic changes in the mucosa. Of course, extreme interference would cause a pathologic condition, with the resultant rapid absorption of the alveolar ridges. In either of these cases, there would be a change, and the dentures would no longer fit.

How many times have men worked faithfully to develop a good impression method, and having mastered it, have found that many points of irritation still occur along the denture borders, and then, after filing or scraping over a period of time with no results and considerable annoyance to both dentist and patient, have had these sore areas clear up immediately on intelligent correction of the occlusal interference that was the cause.

Last year in Washington, while I was discussing some of these problems with Dr. House and Dr. Tench, Dr. House spoke about the innumerable number of times the teeth are brought quite forcibly together every twenty-four hours, in the act of swallowing. The bolus of food hoax is not with us in this unconscious act. It is impossible to estimate the amount of damage that would be done by the exercise of this single function, if the teeth were not in proper balance and in correct centric relation.

Rupert E. Hall has published several articles[1] during the past year, which have criticized this principle, as well as the efforts of some of our great scientists, in bringing to us the means of obtaining it. If much of your time has been taken up on this phase of our subject, it is because of a sincere conviction of its outstanding importance as well as the necessity at this time of keeping it fixed in the minds of the dental profession. It is not with any intent whatsoever, to minimize other important factors in procedure. In my opinion, the steps necessary to obtain the three essentials referred to earlier in this paper are, in the order of their importance: centric relation; balanced occlusion; tooth selection and tooth arrangement; good impressions, and selection of an articulator. It is axiomatic that no chain is stronger than its weakest link. This sequence is given principally to stress the importance of each of these steps. Neglect or inefficiency in any one of them will be

1. Hall, R. E.: Full Denture Construction, J.A.D.A., 16:1157 (July) 1930; Analysis of Work and Ideas of Investigators and Authors of Relations and Movements of the Mandible, ibid., 16:1642 (Sept.) 1929; Analysis of Development of Articulator, ibid., 17:3 (Jan.) 1930.

definitely reflected in the finished dentures.

Vulcanizing has been purposely omitted because of the variety of denture bases in use. Unquestionably, at the present time, vulcanite is the most extensively used material of all the bases, and a thorough knowledge of the behavior of rubber during the vulcanizing process is essential. There are two principal changes which take place during vulcanization and which concern us. The first is expansion by heat, with the resultant contraction when the vulcanite cools. The second is a shrinkage of the mass due to an increase of the specific gravity as a result of vulcanizing. It is important that a careful technic be employed to keep these factors under control, and to reduce the changes to the smallest possible amount. Also, a low heat and low pressure will produce the greatest density with a minimum of brittleness. My preference is the compensating method of vulcanizing as advocated by George B. Snow.

So much has been written about methods of obtaining centric relation that any comments here would seem superfluous. As this step heads the list in order of importance, let us emphasize one or two points. One thing that is important is to check centric relation by an external gothic arch tracing, with which we can transfer to, and control in, our articulator the lateral direction of the mandible as recorded by the patient. Probably the most general method in use for recording this centric position is the use of bite rims. The word "probably" is used here advisedly, because there are some who contend that the antiquated mush bite is extensively used; but it seems impossible to believe this. The bite rims should, of course, be mounted on accurately fitting baseplates of a character that will not be changed under pressure, or by the heat of the mouth during prolonged procedure. Great care should be taken to establish equalized pressure on these rims in centric position. A further check is advised at this point before the rims are locked together. Too much importance cannot be placed on this particular step in procedure, because, if there is an error here, the finished dentures cannot be anything but wrong.

Setting up the teeth is another step in procedure which will merely be referred to because my effort here today is not to discuss details, but rather to stress the importance of basic principles. Any attempt to discuss adequately tooth arrangement would require the writing of a book. The factors that enter into their arrangement are: esthetics, phonetics and functional efficiency.

There have been eras during recent years when it has been a sort of fad to take up, in a serious way, some particular phase of denture work. We have had a wave of impression-taking methods. We have had a wave of articulator building. Just now, we seem to be entering on a wave of new tooth forms. Past experience in the enthusiasm with which men grasped at the particular innovation of the times as a cure-all for denture difficulties would dictate a conservative attitude in tooth selection. After a complete diagnosis, and a careful planning of what can be constructed, such a tooth form as will render maximum service under the given conditions should be selected. I can conceive certain physical conditions wherein one of the tooth forms based on the mechanical rather than the anatomic principle might be the selection of choice. In those cases which present normal conditions, and the vast majority of cases are of this type, it seems to me that we should keep as near to Nature's

form as is possible. This statement is made in full realization of the controversy now going on about this subject, but is based on a desire to give to the patient the full measure of service in all three essentials, namely: esthetics, phonetics and functional efficiency.

The selection of an articulator is completely dependent on the individual operator's knowledge and skill. On the shelves of dental offices all over this country are articulators on which just one case has been constructed. And why are they there? It is because the man who made the case on them did not have any idea of the fundamental principles involved. He bought these articulators in a wave of enthusiasm, and thoroughly believed that some magic power of the instrument would produce results. How much better it would be if this order were reversed, that is, if the man had a thorough knowledge of the fundamentals both in procedure and achievement, and was inspired by this knowledge to select an instrument that would assist him in putting into the finished product the refinements that he had learned and understands.

Prosthetic dentistry is a fine art. A knowledge of the fundamentals in procedure and the finished product is important. But something further is essential. Many of the best judges in our art galleries are not artists. A master does not hand his brush to an artist and direct the painting of a masterpiece. If we want the ultimate refinements in the art of prosthesis, we must put our own individuality into this hopeful masterpiece, and not delegate the technic of execution to some other hands.

CONCLUSION

Let me recall to you a duty which will bear emphasizing. I would wish that I had a sufficient command of language, and a method of expression, that would make this thought ring in the ears of every prosthetic worker throughout the length and breadth of this country. You denture men who have it within your power to control and direct the trend of thought about this subject have a tremendous responsibility. You have the duty of keeping basic principles definitely fixed in the minds of the dental profession, not allowing them to become sidetracked by trivialities or amateurish procedures. Constructive discussion in your section meetings, denture society meetings, and teachers' conferences should be productive of a united opinion as to what the fundamentals of good denture work are. You would, in this way, clear up all this unnecessary confusion, as well as render a service, not only of untold educational value to the dental profession, but also of everlasting benefit to all humankind.

DISCUSSION

Rupert E. Hall, Chicago, Ill.: My criticism of balanced occlusion, to which Dr. McNeely has referred, is admitted by him to be true; namely, the balanced points are not effective with food between the teeth. In what way his and my opinion differ in regard to balanced occlusion I am unable to determine, nor can I see in what particular my writings, to which he refers, are out of accord with the things he has just said in regard to balance.

WHAT IS THE CAUSE OF CARIES AND SYSTEMIC PYORRHEA?

By HAROLD F. HAWKINS, D.D.S., Los Angeles, Calif.

IN dental decay and pyorrhea of the systemic type, we are dealing almost entirely with a metabolic disturbance. Infection plays a part only when the initial damage has taken place. In caries, for instance, the pulp becomes involved only when the enamel is broken and the dentin is exposed to the organisms of the mouth. In pyorrhea of the systemic type, we have a loss of tone of the gum tissue before bacterial invasion is possible. Infection, therefore, is the result of a disturbed metabolism and is not the primary cause of either caries or systemic pyorrhea.

What is the nature of this metabolic disturbance? Can it be measured, and if so, how?

It is a well known fact that caries is very active in rickets. Alfred Hess, an authority on rickets, states that in more than 80 per cent of all cases, there is a very high blood calcium and a low phosphorus content. It has been shown by others, as well as in our own research, that, in active caries, we are dealing with a high blood calcium and a low blood phosphorus condition. We have also called attention to the fact that, in systemic pyorrhea, the calcium-phosphorus balance is just the reverse of that found in caries; that is, a low blood calcium with a high blood phosphorus.

In coordinated saliva, blood and urine tests on the calcium phosphorus balance, we find a very interesting phenomenon; i. e., the salivary balance is just the reverse of that of the blood stream. When the blood calcium is high, the salivary calcium is low, and when the phosphorus of the blood is low, the salivary phosphorus is relatively high. The calcium and phosphorus level of the urine tends to parallel that of the blood stream. This remains true both for active caries and systemic pyorrhea. The accompanying tabulation illustrates this relationship.

RELATIONSHIP OF CALCIUM AND PHOSPHORUS LEVELS IN CARIES AND PYORRHEA

Active Caries	Calcium	Phosphorus
Saliva	Low	High
Blood	High	Low
Urine	High	Low
Systemic Pyorrhea		
Saliva	High	Low
Blood	Low	High
Urine	Low	High

A clinical verification of this relationship can be seen in studying a series of full mouth roentgenograms of carious mouths and those showing systemic pyorrhea. In caries, the roentgenograms show the cancellous spaces of the alveolar bone to be sharply defined and clean cut, and the bone density is high. In pyorrhea, the cancellous spaces are large, and very indefinite, the alveolar crests are flattened and the bone density is low or reduced, as we would expect from the blood calcium level.

In a study of the reactions of the saliva and urine in caries and pyorrhea with the hydrogen-ion test, we find the saliva to

be very acid in active caries, and acid, but not to so marked a degree, in active systemic pyorrhea. In the urine in caries, the reaction is distinctly alkaline when the case is active. In active pyorrhea, the urine is usually very acid, never alkaline. The urine samples for study must be taken from a twenty-four hour or a full night specimen.

May Mellanby has called attention to the fact that she has noted a toxic-like action in connection with cereal or grain foods. Our observations seem to confirm the fact that cereals of all types seem to carry a toxic-like substance that has a distinct slowing up action on the kidneys. We have called attention in previous writings to the fact that an individual on a high cereal diet has an alkaline urine and an acid saliva which contains a very high urea content. This is exactly what takes place in nephritis or when the individual is absorbing toxins in quantity from some foci of infection, with a resulting inability of the individual to eliminate acid phosphates, sodium chlorid and urea.

Let us trace or explain the nature of the metabolic disturbances taking place in caries and pyorrhea. The sequence of events taking place in the development of caries seems to be as follows:

1. A very high cereal or grain diet is taken, which has a slowing up action on the kidneys, causing a retention of acid phosphates, which, in turn, causes acidity of the saliva, also the retention of urea and sodium chlorid, the former of which can readily be demonstrated in the saliva.

2. The retention of acid phosphates and sodium chlorid has been shown by others to cause an increased osmotic tension in the blood stream. Nature compensates by causing the elimination of sodium bicarbonate. Our research tends to show that the alkalinity developed in the urine in caries is not due to alkaline phosphates, but, in all probability, to sodium and possibly calcium bicarbonate, which would lower the alkaline reserve, tending to produce a severe acidosis, especially when acid phosphates are retained.

3. The type of diet responsible for caries is very low in vitamin D, which is necessary for the assimilation of phosphorus. It has been found that even when the diet is adequately supplied with phosphates, if vitamin D is deficient the phosphates are not assimilated. Hence, we have a marked blood phosphorus deficiency, which makes it impossible to eliminate calcium in large quantities.

4. The reaction of the saliva of an individual on a well balanced diet is alkaline. Immune individuals also tend to have saliva with a high buffer action as well as a fair amount of calcium. Such a saliva is capable of neutralizing the acids of fermentation, and thereby protecting the teeth.

The sequence of events in the production of systemic pyorrhea is more or less the reverse of that shown in caries:

1. The subject is usually an adult. The diet is largely meat, fish, eggs, potatoes, bread, pastry and coffee. Observation seems to indicate that, with age, there is an increased ability to handle cereals without the serious kidney-blocking action of youth. The diet is high in acid phosphates and low in calcium. It is a decidedly acid-forming diet.

2. In a state of acidosis, there is a reduced capacity of the body to hold calcium. The large acid phosphate intake gradually combines with the calcium of the long bones as well as that of the alveolar process, and it is eliminated from the body in large quantities. The saliva contains excessive amounts of calcium phosphate. The tendency toward heavy salivary deposits in pyorrhea is an established fact. Pyorrhea patients as a rule

are more nervous than those suffering from caries—another indication of low blood calcium.

3. The tone of the mucous membranes of the mouth is low, owing principally to the acid reaction, which is not the natural reaction for the oral cavity. Salivary deposits that form around the necks of the teeth, owing to the high calcium content of the saliva plus the food residue from cereal foods, increase the irritation of the soft tissues, especially at the gingival aspect. Inflammation, congestion and hypertrophy, with a marked tendency to bleeding, is the usual picture when pyorrhea is active.

4. With the lowered tone of the mucous membrane, infection results. This is largely responsible for the congestion and inflammation seen in pyorrhea. Probably many organisms play a part in this tissue breakdown, which involves the alveolar process as well as the soft tissues. Because they are found more frequently than are other forms in pyorrhea pockets, Vincent's organisms are thought to play an important part in this tissue destruction.

5. When a diet high in calcium, strongly alkaline and moderate in vitamin D is substituted for the faulty one, the character of the pyorrhea changes. The inflammation and hypertrophy tend to disappear and the so-called anemic form of pyorrhea gradually develops. This type of pyorrhea is an intermediate stage between activity and complete arrestment.

With a knowledge of the nature of the faulty balance in caries and pyorrhea, it would seem relatively easy to correct the condition. In caries, this is true if all focal infection is eliminated.

If a serious focus of infection exists, the metabolism is so disturbed as to make it almost impossible for the average patient to secure freedom from caries on an extremely favorable diet. In pyorrhea, suitable instrumentation and pocket elimination should accompany the indicated diet. While the bone density in pyorrhea cases can be increased on a suitable diet, our observation does not lead us to believe that we can hope for the development of new bone if the organic matrix is once lost.

At the College of Dentistry, University of Southern California, a nutritional clinic has been maintained for a number of years in which the diets of the patients have been regulated entirely on the basis of biochemical tests. The ratio of calcium and phosphorus and the degree of acidity or alkalinity are important factors in this regulation. Caries has been completely checked in a high percentage of the children under our control. The work with adults is more difficult on account of the higher percentage of focal infection, and a failure, at times, to maintain the diet.

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C. N. JOHNSON, Editor

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Editorial

THE COUNCIL ON DENTAL THERAPEUTICS

In 1927, the Board of Trustees and the House of Delegates initiated a movement to establish a council on dental therapeutics for the better protection of the profession and the public against questionable methods and spurious proprietary preparations that were flooding the market to the detriment of the citizens of our country.

Preparatory to the establishment of the Council, a chemist was employed to investigate various products, and reports were made in THE JOURNAL. Owing to limitations of space in the office of the American Dental Association, the chemist did his work in the laboratory of the American Medical Association, a courtesy which was greatly appreciated by our organization. The first report appeared in October, 1928, and, following this, a monthly report has been issued with praiseworthy regularity. In 1929, the Council on Dental Therapeutics was organized, consisting of ten men, five

nondental members and five dental members, the former made up of scientists from different sections of the country.

We should like to give expression on this occasion to the keen appreciation which we feel is due every nondental member of the Council for the altruistic and painstaking devotion of these splendid men in an enterprise which has for its object the elevation of our professional status. The Council has given much time and effort to the consummation of an excellent piece of work, and while such might naturally be expected of our dental members, we have the very inspiring spectacle of those following another calling devoting themselves whole-heartedly to an enterprise which can have no tinge of selfishness and no ulterior motive. It is a pleasure to pay this tribute to the Council at this time.

It would hardly be expected that, in a new movement of this kind, there would be an entire absence of misconception or misinterpretation of authority between the executive bodies of the Association and the Council. At a meeting of the Board of Trustees in January, 1930, for instance, the following resolutions were adopted:

RESOLUTIONS

That, after July 1, 1930, advertising of proprietary remedies in THE JOURNAL will not be accepted unless the product and advertising have been accepted by the Council, except in such cases as existing contracts legally obligate the Association to continue advertising copy until the conclusion of the contract.

That the Business Manager be advised not to accept for exhibit in the commercial exhibit proprietary remedies which are not acceptable to the Council on Dental Therapeutics on and after 1931, and that, after 1931, journals carrying advertising matter relative to products not acceptable to this Council shall not be accepted as exhibitors.

No paper endorsing or introducing a new remedy will be accepted by THE JOURNAL until the Council shall examine the evidence submitted and publish a preliminary report.

It is only proper to say that this led to an assumption of authority on the part of certain members of the Council that was hardly warranted, nor was it consistent with the intent or the prerogatives of the Trustees. It at once placed an arbitrary dictatorship over the advertising in THE JOURNAL that threatened to work an unjustifiable hardship on some of our advertisers. This

whole question of advertising requires a sane adjustment, to the end that while we aim for a much needed reform, we do not at the same time work an injustice on any honorable man. We must try to take cognizance of the need of the closest scrutiny of our proprietary products, but we must not proceed on the assumption that every manufacturer or dealer is an arrant rascal, and needs only a club on the head to suppress him. There are just as honorable men in the manufacturing interests as there are in our professional ranks, and our function is to try as best we may to winnow the wheat from the chaff. As rapidly as we can, we are eliminating objectionable advertising, and the authority for doing that must be placed squarely where it belongs, and where it will do the greatest good with the least danger of harm.

In consonance with this, the following action by the Board of Trustees at its meeting February 2, 1931, will clarify the issue:

RESOLUTIONS

Whereas: There has developed some confusion regarding the acceptance of advertising in THE JOURNAL OF THE AMERICAN DENTAL ASSOCIATION, and

Whereas: The acceptance or rejection of advertising in connection with proprietary preparations such as tooth-pastes, mouth washes, etc., is an important matter, and demands the most careful consideration, and

Whereas: The Board of Trustees, in its desire to protect the profession from harmful products and unscrupulous dealers, does not wish to work a hardship on any reputable manufacturer, therefore be it

Resolved: That the Business Manager be instructed to confer with the Council on Dental Therapeutics when questionable advertising of a proprietary product is submitted, and on evidence that it is harmful, or that the advertisement is grossly misleading in its statements, the Business Manager shall request the manufacturer to correct the harmful nature of the product or modify the statements in the advertisement to bring them within the requirements of the Board of Trustees, and in case the request is not complied with, the Business Manager is instructed to reject the advertisement.

Amendment: When a report is published, the product on the market at the present time shall be examined.

These resolutions were passed to take the place of those enacted in January, 1930, and it is confidently believed that they will accomplish two things: they will give every advertiser an opportunity to reform his product and his advertising in conformity with the requirements of the Association instead of summarily refusing

our advertisements without giving the advertiser his "day in court"; and they will also place the responsibility for advertising in the Board of Trustees where it rightly belongs. The Board invites the most cordial cooperation of the Council, fully conscious of the fact that it needs its aid, but the assumption of authority for the conduct of THE JOURNAL must not be usurped by any other body than the Trustees.

This does not mean that the advertisers are not to be held to the strictest accountability in the claims made for their products, or that the Council on Dental Therapeutics is not empowered to pass on proprietary preparations, but that there is to be a more equitable approach toward the entire question to the end that reputable manufacturers may have the benefit of whole-hearted consultation in their problems and a reasonable adjustment of their differences. In other words, what we most need is constructive and helpful effort instead of a continual policy of irritating and unnecessary criticism. This Association will go steadily forward only through the agency of equity and fair dealing, with reform as our chief *motif* and with revolutionary methods only as they are needed for disciplinary and corrective effect. While we should hold every man rigidly to the requirements in any regulation of our products, we should always aim to temper our judgments with consideration and tolerance. And we venture to believe that this policy will stand the test in every activity of life.

BUREAU OF DENTAL HEALTH EDUCATION

TECHNICAL PROCEDURES IN THE OPERATIVE CARE OF CHILDREN'S TEETH*

By ELSIE GERLACH, D.D.S., Chicago, Ill.

WHEN the late G. V. Black wrote his book on operative dentistry, twenty-five years ago, he included two chapters on the care of children's teeth. A few years later, Evangeline Jordon decided to practice children's dentistry as a specialty. These two earnest workers have laid the foundation for the advancement of this branch of dentistry. It was not until recent years that much attention has been given it. A group of capable and hard-working men and women have devoted their time and energy to the education of the public in matters of preventive medicine. Through their efforts, they have attained the recognition of dental defects in children's teeth as a menace to the health of the child.

Every health program in any well organized community includes a mouth examination. This has created a demand for skilful work by dentists in private practice. It is now the duty of every man and woman in the profession, who is temperamentally fit, to take care of the teeth of their young patients. Otherwise, public education will be far in advance of the cooperation of dentists. The days of the 50 cent amalgam filling for children are rapidly disappearing, and in their place appears the day of the demand by parents for the services of skilful dentists. The dental schools are supplying courses in their curriculum to meet the needs of the new times. Apparently, the trend in dentistry will be toward placing this important branch at the head of all its departments.

Generous gifts by such men as Eastman, Forsyth and Guggenheim have made it possible for even the children of the slums to enjoy the benefits of oral health. But, with all this encouragement, it remains for the dentist to do the actual, practical work. To place accurate and lasting fillings in the carious teeth of the child patient should be the aim of all dentists.

As a teacher at the University of Illinois College of Dentistry in the children's clinic, I come in contact with many students, both graduate and undergraduate, and this contact has shown me where many of the difficulties in children's dentistry lie.

The mental approach to the work is important. That we are dealing with children's teeth is no reason for believing that the operative procedures are different from those for permanent teeth. A deciduous tooth has many of the characteristics of a permanent tooth. It has the same shape and form, and is com-

*Read before the Section on Operative Dentistry at the Midwinter Clinic of the Chicago Dental Society, Feb. 4, 1931.

posed of the same materials. The cavity must be carefully and accurately prepared; otherwise, the filling will not hold. The filling materials are the same and are manipulated in the standard way. Contacts must be restored and, finally, it is necessary to polish the filling.

The difference lies in the conditions under which we must work: The patient is harder to keep quiet; the dentist does not like to hurt the child; there is a copious supply of saliva; the mouth cavity and teeth are small, and there is present the ever-wiggling tongue.

As to the restlessness of the patient, a great deal depends on the operator; some have the ability to hold the child's attention and others do not. For the latter, it is often possible to acquire the knack of handling children, if he will but try. The subject of child psychology has a place all its own, and cannot be discussed in detail here.

One must learn how to manage the case when there is a copious amount of saliva. Usually, a child does not object to a saliva ejector. Cotton roll holders are helpful. Sometimes, best results are gained by twisting a small wad of cotton into a roll. Often, the hard, sharp edges of the commercial cotton roll are in themselves irritating to the mucous membranes and will cause a flow of saliva. Many children will even tolerate a rubber dam. When all else fails, I have found that I must hold a cotton roll, one on each side of the tooth, with the fingers of my left hand. This is rather tiresome for the operator, but is probably the most effective way of keeping the tooth dry.

When the tongue becomes too active, I tell the patient to take deep breaths through the nose. This usually attracts his attention to the breathing, and he forgets the tongue.

When a cavity is to be prepared, it is advisable to start with a hand instrument. Many children are afraid of the bur, because they have heard an adult relate experiences about the drill. All instruments and burs should be sharp. I start with a chisel, and, with it, outline the cavity. I excavate with spoon-shaped excavators until all the carious dentin has been removed, and, finally, with a bur, gently and slowly complete the cavity preparation. If the cavity is a proximal on a molar, a step broad and slightly dove-tailed must be cut on the occlusal surface unless there is no approximating tooth. The occlusal step gives the necessary anchorage. I have seldom seen a proximal filling in a deciduous molar remain in place unless there was a good occlusal step to hold it. Failure to provide this step is one of the most common reasons for poor results in filling deciduous molars.

Another mistake often made is to cut away too much of the lingual and buccal walls. To obtain good anchorage, it is necessary to maintain as much of these walls as possible. The more that is cut away, the deeper into the axial wall and gingival wall must the cavity be extended. This brings the axiogingival angle near the pulp and, at this point, most of the accidental exposures are made. It must be borne in mind that, in proportion, the pulp chamber in a deciduous tooth is larger than the pulp chamber in a permanent tooth. If, during cavity preparation, the child suddenly complains of pain, this is a warning that the instrument is very close to the pulp, and it is well to make a careful investigation, keep away from that spot and place an insulator over it. I have found that thymolized calcium phosphate mixed with just enough eugenol to keep the particles together is a very effective capping material.

Chemically pure zinc oxide—chemically pure because ordinary zinc oxide usually contains traces of arsenic—mixed with eugenol into a very thick, almost dry paste is also a very safe capping material. Just enough paste should be applied over the deep spot to cover it lightly. A zinc oxyphosphate cement base is placed over the capping. In cavities of any depth, it is advisable to follow this procedure because most pulps die under large metallic fillings in deciduous teeth from thermal shock, or a minute exposure of the pulp, which might have been saved with a capping.

When the otherwise well-behaved child begins complaining of pain and there is still a large amount of carious dentin in a large cavity, undoubtedly there will be an exposure of the pulp. One of two choices remains: either to expose the pulp deliberately and treat as a healthy vital pulp, or to take a chance at capping. Either one will keep the operator guessing, but I prefer to remove a healthy pulp rather than to treat an abscessed tooth, should the pulp capping fail. Removing a vital pulp (under a local anesthetic, of course) is not going to make one very popular with the patient for the time being, but you are performing a service which will be of the highest benefit to the child's mouth. I hope that you are all fortunate enough to have your child patients come to you before root canal work becomes necessary.

It is important to notice before cavity preparation is begun, whether the mesiodistal length of molars has been shortened because of loss of tooth structure. If length is lost, trouble will arise when the bicuspids erupt. In order to secure the necessary separation, I pack and slightly overfill the cavity with baseplate guttapercha. This should remain for at least three or four days and will tend to wedge the teeth apart. Too great mesiodistal length is better than not enough.

In the filling of molars with amalgam, a matrix should always be applied. Most of the mechanical matrices are very cumbersome in a small child's mouth. The one that I find most useful is the type suggested by G. V. Black. It takes a little practice to learn to adjust it easily, but it is well worth the effort.

A small strip is cut from a sheet of copper matrix material slightly greater in width, to extend from the occlusal surface to the gingival, and long enough to half encircle the tooth. Two slits are cut about one-third the distance of the length from each end. The two outer flaps are bent back and the middle third cut away. A piece of cotton floss about 10 inches long is placed under the flaps, and fastened down tightly with a plier over the floss. Then, the matrix is placed against the tooth, with the flaps to the outside and against the gingiva. The floss encircles the tooth, one end coming through from lingual to buccal aspect, the other from buccal to lingual, and the floss is tied on the buccal side with a surgeon's knot. The ends of floss are cut off and, with a burnisher, the band is adapted to the desired shape. The cavity, after being sterilized with phenol compound and dried, is now ready to receive the amalgam filling.

When the amalgam has set sufficiently that the matrix can be removed, the floss on the buccal side is cut with a sharp instrument. The ends of the matrix are bent away from the filling, the flap cut from the matrix on the lingual side and then, with the buccal end grasped with a plier, pulled carefully through the proximal space. I never attempt to pull the matrix through at the occlusal aspect, for usually the filling comes with it. The

filling is carefully carved to occlusion, or, when the child bites, the filling will be cracked. At a subsequent sitting, it should be polished.

When there are approximating cavities on the molars, it is advisable to fill only one at each sitting. In the use of the matrix, applying and removal will disturb the partially set amalgam in the other tooth.

In making restorations on molar teeth, silver amalgam is probably the most satisfactory filling material. It restores the necessary bulk, and because it does not dissolve proximally, the mesiodistal length is maintained. It is a good wearing material and, when properly handled, it should last as long as the deciduous tooth remains; whereas, the cements necessitate frequent replacements. At all future appointments, the dentist should look for shiny spots on the filling. The amalgam does not wear down so fast as the enamel because it is harder. Consequently, occlusion is slightly interfered with and, in the developing jaw, all such disturbances should be carefully avoided.

Copper amalgam is a satisfactory filling material when it can be kept from flowing under occlusal stress while it is setting. This is usually difficult to control, and most of the proximal-occlusal fillings become distorted.

When there is proximal decay on the first deciduous molar and the cuspid, there is usually considerable loss in mesiodistal length and to restore proper contacts is rather difficult. Baseplate guttapercha should be packed in the space for twenty-four hours before the fillings are placed to secure separation. Silver amalgam is a good filling material for the distal side of deciduous cuspids, provided enough retention can be made.

The filling of anterior deciduous teeth is a rather difficult task. Most of the fillings drop out as soon as they are placed. This is due to the fact that the pulp chamber is large, and it is difficult to get retention without exposing the pulp. The choice of a filling material becomes an important consideration. The silicate cements are contraindicated because they usually cause the death of the pulp. Zinc cements usually wash out rapidly. In these cases, I have found that when zinc oxid is mixed into a very stiff paste with eugenol, it acts as a satisfactory filling material. Because it is nonirritating to the pulp, the cavity may be made very deep, and thus retention be gained. It does not develop heat while hardening and the fluids of the mouth do not affect it. Its disadvantages are that it takes about an hour to become hard in the tooth. Contacts cannot be restored with it, because it is brittle and does not stand stress. But while some of it may wear off, usually the portion in the deep part of the cavity remains without change, thereby protecting the vitality of the pulp. It is also of a chalky white appearance, which makes it conspicuous, but this is to be preferred to the silver nitrate discoloration which is recommended by some operators. Probably all of you have experienced the feeling of discouragement arising when a 4 or 5 year old child comes to you with all the anterior proximal portions of the teeth decayed. Usually, the teeth are small, thin and crowded, painful on which to work. I use a small inverted cone bur to prepare the cavity, being careful not to destroy more of the labial and lingual walls than is necessary, in order to retain depth for retention. Then, I fill this with zinc oxid paste and instruct the patient not to eat for at least two hours. This allows sufficient time for hardening.

The use of silver nitrate has been recommended for these anterior teeth,

and when all else fails, this is a most satisfactory way of handling them. The decayed surfaces are polished with sandpaper disks and then the silver nitrate is applied and reduced with eugenol. I do not like to use silver nitrate. First of all it discolors the teeth, and the child loses interest in the appearance of his teeth. It is a dangerous drug to use. In a weak solution, it is not very effective. In a stronger solution, it burns deep into the tissues, if, by accident, it should come in contact with them. The child is apt to move and thereby cause the solution to come in contact with the tissues, or he may upset the receptacle and spill the solution on himself. Common salt, its antidote, should always be at hand to be applied immediately in case of accident. I am also afraid that silver nitrate is often used to cover an area which might better have been removed by an excavator. It gives the operator a false sense of security when decay is thus treated.

Phenol is another drug which should be used sparingly in a child's mouth. A careless or accidental contact with the mucous membrane results in many days of real suffering for the patient. If it should be spilled on the skin, alcohol should be applied immediately, followed by a bland ointment.

The copper cements are indicated in those cases in which the patient is too young to be managed in the chair long enough for an amalgam to be placed; also, in case the patient will not cooperate, so that it is impossible to keep the cavity dry. It should be remembered that if the cavity is very deep, a base of nonirritating substance should first be applied, as the acid in black copper cement may cause the death of the pulp. The cement sets rapidly and therefore everything should be in readiness before the filling is mixed. Before dismissing the patient, I make sure that the filling is not too high, as traumatic occlusion injures the peridental membrane of a deciduous tooth as much as it does that of a permanent tooth.

Unless the fluids of the mouth are tolerant to cements, the black copper cement filling will need frequent renewing. This causes a great waste of time, and as soon as possible, the cavity should be prepared for the reception of an amalgam filling.

Occasionally, we encounter a case in which the enamel of the deciduous tooth seems to have crumbled away. This may be due to the enamel's being improperly formed and weak. In an unfavorable environment, it is quickly worn away. The dentin, although discolored, may be very hard. To restore with amalgam would be impossible and placing gold crowns would be a very tiresome procedure for the child, besides a great expense to the parent. The best we can hope to do is to keep the pulps alive so that the roots will not be lost. I try to gain as much retention as possible by running a small inverted cone bur around the edge of the remaining stump of the crown and a few pits into the occlusal surface. I dry and sterilize the surfaces with phenol compound and cover with black copper cement, shaping it into a sort of flat cap and endeavoring to build it up on the occlusion to keep the bite open in the molar region. For the anterior teeth, I use either zinc oxid fillings or protect with silver nitrate. Frequent renewal of fillings becomes necessary. It is easily understood how discouraged the child and parents may become, and it behooves the dentist to use every means to interest both in forming habits of immaculate cleanliness in oral hygiene. If nutrition and general hygiene are taken care of, the second set of teeth should

appear in good condition unless there is something organically wrong with the child. It has recently been my privilege to supervise the dental work which is being done for the children in one of Chicago's foremost orphanages. These children have been taken from most unfavorable environment and placed in homes where proper supervision is given to mental and physical health. The mouth conditions were changed from bad to excellent in a comparatively short time. They entered in a poor condition of health, due mostly to undernourishment. Their mouths were in a pitiful condition. All teeth showing involved pulps were extracted, and the cavities filled. The children were given a suitable diet, and cod liver oil was administered in large quantities. The improvement is hardly believable. Caries has been arrested; the gums are pink and firm and the teeth clean. Salt instead of toothpaste has been used on the toothbrush.

So far, this paper has considered the child up to the time of the eruption of the first permanent teeth. At this age, new conditions are presented which require different procedures. When the first permanent molar erupts, our troubles commence in earnest. Both the parents' and dentists' failures in the early care of the child's mouth now become evident. Neglected deciduous molars have been extracted, leaving a space into which the first permanent molar can shift. Early loss of anterior deciduous teeth causes a crowding of permanent anterior teeth or a delayed eruption. Until the first molar is fully erupted, it is hard for the child to keep it clean, and usually when an explorer is placed in the fissure, a definite catch is felt. Now the dentist must decide whether to fill these fissures. If the mouth is susceptible to decay, it is most advisable to protect this occlusal surface. I clean out the fissures and, if necessary, deepen them and fill with black copper cement until the tooth is fully erupted. A newly erupted tooth is very sensitive, and only the most necessary operative work should be done on it. If the explorer sinks into the fissures to any depth, a good occlusal cavity should be prepared, including all the fissures and extending for prevention. We must not put off taking care of it because, in a few months, there may be an exposure, or near exposure, of the pulp. When decay starts in these molars, it usually spreads rapidly. This is especially true of clinic patients who come in for dental care only when they have a toothache. We fill the occlusal cavities with amalgam, for usually, in a few years, proximal decay occurs; when it becomes necessary to place a gold inlay.

When these first molars erupt and are in a hypoplastic condition, each little pit as it decays should be filled with black copper cement to keep the decay from spreading into the dentin. When all molars are entirely erupted, onlays may be made to order to keep the bite open. If the entire crown is weak, gold crowns are the most satisfactory. They may be placed at an early age.

If hypoplastic teeth are kept very clean, little or no decay occurs; but, in a neglected mouth and especially if much candy is consumed, these weak places decay rapidly. On the anterior teeth, they present a very disagreeable picture. It is not advisable to put porcelain jacket crowns on them at a very early age, but if the pulp can be well protected, a synthetic porcelain crown may be made. The celluloid forms are very convenient for this purpose. Usually, the patients, especially if they are girls, are delighted with the difference it makes in their appearance. If they are reasonably careful,

these synthetic crowns may last for several years.

When proximal decay occurs in normal healthy anterior teeth, regular Class 3 cavities may be prepared, and an oxyphosphate of zinc cement is placed over the pulp as a base. Then, the cavity, may be filled with synthetic porcelain. In most normal mouths, this filling will stand for several years, provided it has been placed with skill and care.

Some children's permanent teeth present a very trying situation. This is especially true of the adolescent. Much proximal decay is present and the fillings seem to wash out as fast as they are put in. The decay travels quickly through the dentin and, before we know it, there is a pulp involvement. The enamel seems brittle and crumbles under slight pressure. If this condition is of sudden onset there may be something radically wrong with the patient's metabolism, and the physician's cooperation should be immediately sought. The diet may be wrong, and the condition may be aggravated by anemia or by glandular disturbance. The carbohydrate intake may be too great. Adding plenty of fresh fruits, vegetables, milk and dairy prdoucts to the diet may be of great help. Probably, more fresh air and sunshine are also necessary. The child is indeed fortunate who has parents who understand the adolescent and can plan the environment so that the child takes part in a healthy plan of life in a natural way.

In so many of these cases, the child feels abused and refuses to follow a sensible program. The dentist also suffers from it, for unless the child receives proper medical attention, all the dental care will be of no avail. Usually, the condition stops as suddenly as it starts, and then restorations of a more nearly permanent nature can be undertaken. Until then, we should do all in our power to keep the pulps vital and to save as much of the tooth structure as is possible. Silicate cements when placed over an unprotected pulp will kill it in a short time. The use of zinc oxid and eugenol paste as a temporary filling, while it is not a very attractive filling material, seems to be as beneficial as any.

Gold foil is contraindicated because of the very nature of conditions. The apices of the roots are not completely developed, the bone is not so dense as in later periods and the decay usually progresses, making a new filling necessary in a short time. The blow of the automatic hammer is a severe strain on the child's nervous system as well as on the young tissues of the tooth. The gold foil filling should be delayed until the apices of the teeth are fully closed.

When a permanent front tooth is broken off by a fall or a blow, and there is no pulp involvement, it may be covered with a gold shell crown and the labial surface cut out and filled with synthetic porcelain. When there is pulp involvement and the pulp is removed and closed with a root canal filling, a crown may be placed at an early age.

The dentist who sees only the cavities in a child's mouth and fills them is doing well, but he could render his patient a still greater service if he would keep alert to habits which cause malocclusion. To watch for them is as much a duty as it is to watch for caries. Most of them are well established before the permanent teeth make their appearance. Parents are rarely aware of them and are most surprised when they are pointed out to them. They become so accustomed to seeing a child repeat a certain act that they finally become unaware of it.

One of the most disfiguring deformities is caused by the habit of mouth breathing,

even though the nasal passages may be free. We should call the attention of both child and mother to it frequently so that it may be broken as quickly as possible. It is a very difficult habit to overcome and one that does more harm than most of the others. The earlier the habit is noticed, the easier it will be to break it.

Thumb-sucking usually does not persist so long because parents are more aware of it, and a child is easily shamed out of it.

Another habit which is not so noticeable is the one of drawing in the lower lip and biting it. It not only causes a malocclusion of the teeth, but also the lower lip becomes thickened and enlarged. Holding the tip of the tongue between the anterior teeth soon causes an open bite.

Sleeping with the head in the same position and especially when complicated by pillow habits is another one of the practices which should be broken in early life, as it causes a crossbite.

When children start to school, they may develop such tricks as pushing the point of a pencil between the teeth, which generally causes a separation of the teeth. They may learn to rest their heads on their hands in such a way that the fist is always pushing in one one side of the face, causing a lingual occlusion.

Youngsters who have tantrums may grit the teeth and bite with the anterior teeth edge to edge. Soon the lower may protrude and cause a typical Class 3 malocclusion.

Early habits of mouth hygiene are essential, and no better service can be rendered by the dentist than preaching the gospel of the toothbrush from the very first. Children who come from homes where the parents are fastidious about mouth hygiene usually learn by imitation, and little trouble is experienced with them. Most trouble arises in teaching children to brush the posterior teeth, especially around the buccal side of the upper molars.

Constructive criticism, praise when it is deserved and appeal to pride are the best ways of securing cooperation in the tooth brushing game. More often, it is necessary for the mother to help the child brush his teeth, especially around the molars. Consequently, adequate instruction must be given to the mother or nurse. In a few instances, I have known the father to be the parent most interested.

In the extraction of baby teeth, great care should be exercised. Before pulling one which is firmly attached, I ascertain by a roentgen-ray examination whether there is a permanent successor. It happens more frequently than is suspected that a permanent tooth is congenitally missing. I know of a case where all of the deciduous molars with long strong roots were extracted from the mouth of a 12-year-old girl. When the permanent teeth did not erupt, roentgenograms showed that the permanent teeth were missing. Consequently, the girl is wearing partial dentures.

Whenever the extraction of an infected deciduous tooth becomes necessary, I make sure that all of the roots are removed. Too often, during a hasty or careless operation, parts or the whole of the root remain in the tissues. These may not give any particular discomfort to the patient, but they are liable to become wedged between the erupting permanent teeth and cause a separation.

Sometimes, very robust children lose the deciduous teeth at a later date than is usual, and no particular damage results. In others, this may cause much harm. In many of the latter cases, it is due to lack of proper function. The child may never chew any hard food and there-

by no stimulation through exercise is given the underlying tissues. Roentgenograms usually show that absorption of the roots is not taking place. In such cases, the permanent teeth may erupt behind the deciduous. The deciduous teeth should be pulled immediately. Abscessed teeth may hasten the eruption of the permanent teeth.

In all cases in which deciduous teeth are extracted, and a roentgenogram shows that the development of the permanent teeth has not proceeded very far, a space maintainer should be placed.

One of the usual difficulties which some dentists experience is to give parents information without tangling themselves in a group of words having little or no meaning to the average layman. I would advise all dentists to read the articles pertaining to health which appear in the home magazines. They are written by men and women who have the ability to explain to their readers in simple langauge the things which are of interest and importance to the parents. They are up-to-date and interesting. They accustom the dentist to "put across" a point. For the practitioner who is not particularly interested in following the newer theories in nutrition, they present a kind of A B C in this important field. They give many valuable aids in helping to interest children in eating the proper kinds of foods and in breaking undesirable habits. Most modern mothers read these articles, and may be ahead of the dentist in many of the modern theories of child welfare.

SUMMARY

When the operative care of a child's mouth is entrusted to a dentist, he should endeavor to give the best of his skill and knowledge. On him depends the guidance which will lead the child to a healthy adult mouth. He should be the first to notice any change which is occurring in the development of the teeth and jaws, and to interpret these changes correctly. He should be able to foresee any unfavorable influence, and should have the knowledge necessary to forestall disastrous consequences.

When every dentist, to the best of his ability, shoulders his responsibility in the dental care of children, the profession will be doing its part to fulfil the program outlined by President Hoover at the White House Conference when he said: "Let us make the world a better place for the growing child."

THE PHYSICIAN'S VIEWPOINT ON DIET IN RELATION TO CALCIUM METABOLISM*

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THAT a physician should be asked to present his point of view on an important problem of physiology and biochemistry before a group of dentists is significant. It implies that different groups of men interested in that problem are not entirely in accord and desire to hear all sides of the question. Such an attitude of mind is proper. It has always been my belief that dentistry is a medical specialty and should never have been so distinct and separate a profession as it has been in the past. Our problem is one: the health of the individual. Our "jobs" overlap.

Problems of diet and metabolism concern the whole body, and that includes the teeth. Disturbances in the teeth affect general health, and this does not refer to the problem of focal infection alone. Often, the condition of the teeth offers an index to a state of general metabolism.

The problems related to calcium metabolism are of especial importance to you; that is self-evident. The physician is also much concerned with these problems. Most especially do they concern the pediatrician, as he deals with the growing child.

Calcium is an essential element in our body economy. It is derived from the soil, and we obtain it either directly or indirectly from plants. Some plant foods and some foods of animal origin contain calcium in different concentrations. In order to prescribe a diet that will maintain a proper calcium balance, we must know how much calcium is required and how it may best be ingested to secure the desired results. We must know the conditions that are favorable to its absorption, assimilation and excretion. In recent years, we have learned to recognize certain accessory food substances which are necessary in normal metabolism. In the field of calcium metabolism, vitamins play a leading rôle. The sources of these vitamins and the methods of their proper administration must be familiar to us.

Under normal conditions, the blood serum contains from 10 to 11 mg. of calcium per hundred cubic centimeters. The calcium requirements of the body tissues are supplied by this circulating calcium. The maintenance of a normal serum calcium depends on the demands made on it by the body tissues, the supply of calcium brought to it from the digestive tract, that is, from the food, and the presence, from some source, of vitamin D. Calcium may be said to be stored up in the tissues, particularly, of course, in the bones. The bones then, according to some observers, become the great reservoir for calcium in the body, from which it can be drawn under certain conditions of great demand, as, for example, in pregnancy and during lactation, and during the period of rapid

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growth of infants, especially premature infants. If the amount of calcium ingested is insufficient, or if absorption of calcium from the intestines is interfered with, and if the other conditions necessary for proper calcium metabolism, particularly the accessory foods or vitamins, are not present, a negative calcium balance results, and, in time, the bones are depleted of much of their store. Osteomalacia is known to occur in pregnancy and in times of extreme economic stress when proper food is not obtainable.

Hamilton[1] demonstrated that the amount of calcium oxid in the full-term new-born infant averages 10 gm. per kilogram of body weight and that the body as a whole becomes relatively less rich in calcium after birth. At a normal rate of growth, he would have to retain about 160 mg. of calcium oxid a day through the first two months in order to maintain this ratio, but he actually retains less than half this amount. The relative decrease in calcium continues until it reaches its lowest level in the fourth or fifth month, after which it increases slowly. The decrease in the relative calcium content of the whole body after birth means that the bones are becoming poorer in calcium. The bones at birth probably contain an excess, which is used up by the fourth or fifth month. But from then on, there is an increase in calcium retention from the food. After that time, then, all the calcium needed for growth must come from the food. If the body is unable to use the calcium ingested, the result is an insufficient supply of calcium for growing bone.

Food contains calcium in both organic and inorganic combination. It is probable that, through digestive changes, it is converted entirely into the inorganic form, so that it is absorbed from the small intestines as a mixture of inorganic salts and calcium ions. A variable but considerable amount of the ingested calcium is reconverted into insoluble salts and passes through the digestive canal unabsorbed.

In attempting to judge the amount of calcium absorbed, we are confronted by many difficulties. Many variable factors have to be taken into account. It is not simply a matter of estimating the amount of calcium ingested and substracting the amount of calcium excreted, for it is known that some of the calcium that is absorbed from the small intestines is again excreted through the bowel, without having been used by the tissues, and it is impossible to differentiate this calcium from that which has never been absorbed or from that being lost from the bones. There are variations in absorption depending on the relative amounts of calcium and phosphorus in the diet. Orr, Holt, Wilkes and Boone[2] showed that excessive amounts of phosphorus in the diet exercise an unfavorable influence on calcium metabolism and are accompanied by an increase in the calcium lost in the feces.

Holt, Courtney and Fales assert that, in infants, the best absorption of calcium obtained when the intake bore a definite relationship to the fat intake. There are also changing conditions in the digestive tract which influence calcium absorption. Then, too, fluctuations in the requirements of calcium occur, dependent on the age and the rate of growth. The relation between the amount of calcium retained and that ingested is extremely variable. We can give no constant relationship because it is dependent on so many varying conditions.

1. Hamilton, B.: Boston M. and S. J., 191: 339-341 (Aug. 21) 1924.

2. Orr, W. J.; Holt, L. E.; Wilkins, L., and Boone, F. H.: Am. J. Dis. Child., 28:574-581 (Nov.) 1924.

Vitamin D is the essential factor in calcium retention. The actual process by which vitamin D exerts its favorable action is not definitely known. It is probably an intermediary reaction which allows the tissues to retain calcium rather than one which improves calcium absorption or that hinders calcium excretion. In rickets, for example, the blood calcium is frequently normal, but the bones are low in calcium, which indicates that the tissues are unable to retain the calcium even though a sufficient quantity is being brought to them. When vitamin D is supplied, calcium is again properly retained, regardless of the diet. But that this cannot go on for long without an adequate supply of calcium in the food has recently been shown by Sherman and Booher. Rickets can be regularly produced in the young growing animal either by a deficiency of calcium, of phosphates or of vitamin D in the diet. In the presence of an ample amount of vitamin D, much smaller amounts of calcium and phosphorus are sufficient to prevent rickets than when there is a small quantity of vitamin D present.

Mellanby[3] states that we have as yet practically no knowledge as to the intimate mode of action of the specific dietary constituents on the bones and teeth, but we know that vitamin D is the most important factor. His experiments show that (1) when the vitamin D intake is high and calcium and phosphorus intake is low, perfect calcification of bones and teeth will ensue; (2) when the vitamin D intake is moderate, increasing the calcium and phosphorus intake will improve the calcification of bones and teeth; (3) when the vitamin D intake is very low, however high the calcium and phosphorus intake, imperfect calcification of bones and teeth will result, although not so imperfect as would have been the case had the calcium intake been low.

The actual effect of the diet in the arrest and prevention of dental caries has been studied by several investigators in recent years. Boyd and Drain[4] observed that diabetic children showed arrest of caries after they had been on a diet in a hospital for six months. An arrest of caries was not observed in the case of other children in the hospital for treatment of other diseases. They concluded that this arrest of caries must depend on some factor in the diabetic management. In the diet of these children, fat instead of carbohydrate was the chief source of energy; otherwise, it furnished the essentials of a complete diet according to our present knowledge: milk, cream, butter, cod liver oil, eggs, meat, vegetables, fruits. A considerable supply of mineral salts and vitamins was thus ensured. The ash of the diet was predominantly basic. These patients ate regularly and under supervision a diet more in accord with the needs of a normal child than the average child receives, particularly in regard to accessory food substances and minerals.

The evidence points to caries' being dependent on metabolic disturbances. Such disturbances may depend in part or wholly on the character of the food intake. Dietary deficiencies result in disturbance of the mineral balance. Calcium is readily mobilized from the bones and teeth when needed for the regulation of mineral metabolism. With correction of conditions which lead to metabolic disturbances, the teeth develop resistance to

3. Mellanby, Edward: Brit. M. J., 1:677-681 (April 12) 1930.

4. Boyd, J. D., and Drain, C. L.: J. A. M. A., 90:1867-1869 (June 9) 1928; Boyd, J. D.; Drain, C. L., and Nelson, M. V.: Am. J. Dis. Child., 38:721-725 (April) 1929.

caries. Requirements of growth of the child keep him continuously near the danger line of metabolic imbalance.

Later, these investigators studied a small group of nondiabetic children on the same diet without insulin, and in these there was likewise a complete arrest of dental caries. Two of these children were further observed when put back on a general ward diet, with the result that, after several months, both had active caries. Two children with celiac disease who had active caries were put on a diet in which the calories were supplied chiefly by sugars and other simple carbohydrates, with practically no fat, but with twice as much protein as the other children had had. In addition, their diet contained a rich supply of minerals and vitamins from fruits and vegetables. The caries of these children was similarly arrested.

In one series of cases, the fats were high and carbohydrates very low; in another, the fats were very low and carbohydrates in the form of simple sugars high; in all, the protein was kept at 1 gm. per pound of body weight or more. Each received cod liver oil, orange or tomato juice, vegetables, fruit and milk daily in amounts designed to meet the requirements for vitamins and minerals. Whatever the factors responsible for dental integrity, they are apparently supplied by these foodstuffs. These experiments indicate that tooth decay is dependent primarily on metabolic changes. Adequacy of the diet in all essential factors is necessary.

Great interest has been aroused by the experiments of Mellanby and his coworkers who claimed to have proved that common foods may contain both protective and harmful elements as regards calcium and phosphorus metabolism. It was found that cereals interfere with the calcification of bones and teeth. Oatmeal does this to the greatest degree, while white flour interferes least; corn, rye, barley and rice lie between these extremes. The harmful effect is due more to the germ of wheat and of corn and probably of the other cereals, and less to the rest of the grain. They further demonstrated that when vitamin D in sufficient quantity was supplied, no matter from what source, the decalcifying effect of cereals was overcome. In experiments on dogs, they showed that (1) proper calcification of the teeth can be produced by the ingestion of sufficient vitamin D during the formation of the teeth; (2) well calcified teeth are less susceptible, and poorly calcified teeth more susceptible to caries; (3) independently of their original structure, the inclusion of sufficient vitamin D raises the resistance of teeth to caries and may even arrest the carious process; whereas, diets deficient in this substance, especially if they contain much cereal, allow a lowered resistance to caries, and a more rapid development of this condition.

We may summarize what seem to be the important things in the relation of diet to calcium metabolism in this way: 1. Calcium is an essential element in the body. 2. Calcium must be supplied in sufficient quantities in the food. 3. The diet must be adequate in all the essential constituents including the vitamins. 4. Vitamin D in sufficient quantity whether supplied by cod liver oil, viosterol or irradiated foods, or by direct exposure to ultraviolet rays, is absolutely essential.

The growth and integrity of the bones and teeth probably are influenced by several conditions other than those strictly implied in the title of this paper. A deficiency of vitamin C in the diet of the growing infant and young child leads to profound disturbances in bone growth. These disturbances have to do with an in-

terference with osteoblastic activity rather than with calcium metabolism. Recently, the investigations of Hanke and others seem to show that the health of the teeth is improved when attention is paid to the administration of an adequate quantity of vitamin C. This again is probably due to reestablishing normal activity of odontoblasts rather than to its effect on calcium metabolism. It is possible also that other accessory food substances exert an influence on bones and teeth, but as yet we have no proof that such is the case. A discussion of calcium metabolism from any point of view would not be adequate without reference to the parathyroids. We are all acquainted with the profound changes which take place in calcium metabolism when the parathyroids are removed experimentally from animals. Varying degrees of parathyroid efficiency in man may well be responsible for some of the individual variations in his calcium metabolism. There are also constitutional peculiarities in bone growth and tooth growth for which we have as yet no explanation. As I have tried in this paper to confine my remarks more or less strictly to the question of diet in its relation to calcium metabolism, these interesting phases must be mentioned only in passing.

The average child, except among the very poor, has offered to him a fairly adequate diet in nearly all its essentials. Probably the most common inadequacies relate to the minerals and to some of the accessory substances, particularly vitamin D. Often, the individual has the proper diet offered to him, but for various reasons does not actually take enough. Education of the parents not only in dietary requirements but also in feeding technics is necessary. Improper intake of food when offered is most often due to a poor condition of mental hygiene in the home, and a proper mental attitude of the parents and of the child must be brought about or the finest program of dietary management will come to naught. To prescribe a diet is easy, but to have it taken is another thing. When giving advice about diet, let us be clear and concise and above all be practical. A menu must be attractive and practical or it will not be continued for any length of time. It is not practical for an individual to drink from 1 to 2 pints of orange juice a day or to eat a whole head of lettuce and six stalks of celery, in addition to large servings of at least three other vegetables a day, and keep this up over any long period of time. When we prescribe like that, if the diet is adhered to, other essential foods are crowded out, and we defeat our own purpose by producing a metabolic imbalance from another angle. Digestive disturbances may also ensue, and then a whole rearrangement of diet is necessary. Let us be fair to the men who are making important contributions to our knowledge of the essentials of diet by interpreting their conclusions honestly, not discrediting them by putting into practice ideas which we imply have come from them but which in reality constitute our own interpretation. Our enthusiasm over some newly discovered truth or partial truth must not lead us into faddism. We must try to see the thing as a whole with all the features in their proper relationship one to another.

A reasonable amount of orange juice is a good thing, but that does not mean that ten times the amount usually given is better. That cereals, particularly oatmeal, have been shown to exert a harmful effect on calcium retention does not mean that cereals must be omitted; it simply means that there must be a sufficient

amount of vitamin D present when much cereal is given. The fact that whole wheat bread is a more complete food than white bread does not infer that white bread should never be eaten; it means merely that if white bread is eaten, care should be taken to supply whole grain elements in some other form. Overenthusiasm sometimes robs us of a proper perspective of the whole.

Better teamwork among physicians and dentists in the field of dietetics, and a more sympathetic and intelligent understanding of each other's problems is essential if we are to get the desired results.

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CURRENT LITERATURE

EXTRACTS AND ABSTRACTS

Dental Sepsis and Mental Disease: That there is danger of confusing cause and effect in cases of mental disease associated with dental sepsis is pointed out by Arthur Bulleid (*Brit. Dent. J.*, Nov. 5, 1930). The case is cited of the patient who, suffering from dementia precox, neglects his teeth, which, as a consequence, show obvious signs of disease. In most cases, serologic tests will determine whether dental sepsis is the direct cause of a general systemic lesion. Most cases of autotoxemia, productive of any mental symptoms at all, are attended by what may be called infective exhaustive psychosis, and, in this group of cases, no doubt removal of septic foci leads to amelioration or cure of the mental condition. In the absence of other cause, and with serologic confirmation, one can be assured that dental sepsis was the cause of the mental illness. Experience in many cases of insanity is tending to support the contention that with the exception of the infective exhaustive psychoses, practically no mental illnesses are the direct result of physical ailments. In some cases, as simple depression or maniacal attack, recovery would normally be anticipated without special treatment, and if dental sepsis was eliminated, the cure would be erroneously ascribed to this fact, and the case would be cited as proof of physical ailment causing a mental condition. Another common error lies in ascribing recovery to removal of septic foci, when it is in reality due to suggestion, based on the care and attention given the patient by physician and dentist, and the belief of the patient that their procedures in his behalf will eventuate in cure. Unfortunately, it is difficult to obtain control cases, and on this deficiency is based one of the criticisms against the conclusions of Cotton and Hunter. The author advises the eradication of all septic foci in mental conditions as a general health measure, and urges that the physician and dentist cooperate in giving careful attention as to the most advantageous time for the work and in determining over what period it should be carried out if there is much to be corrected.

Recent Advances in Methods of Administering Nitrous Oxid in Oral Surgery: F. P. de Caux (*Cur. Res. Anes. Anal.*, November-December, 1930) believes that there is overwhelming evidence that nitrous oxid, when administered by an experienced anesthetist, is by far the most convenient and the safest anesthetic for all dental operations, no matter of what length. Cooperation of dental surgeons would result in an increase in the demand for this form of anesthesia and, as a result, an adequate number of skilled administrators would be available, affording better service to patient and surgeon. The nasal and endotracheal methods of administration solve the problem of prolonging anesthesia and leaving the mouth free for the surgeon's needs. Anesthesia is induced and maintained by replacing the air in the lungs by nitrous oxid. Oxygen is added to prevent asphyxia, and, given in proper amount, does not impair the effects of the nitrous oxid. A gas and oxygen mixture is easier to administer than gas and air because, in the latter, the percentage of oxygen varies continually. Gas and air is preferable in cases lasting only five minutes or less as it acts more rapidly; in protracted cases, gas and oxygen is to be

preferred. The endotracheal method of administration consists of admitting the anesthetic vapors to the lungs by means of a tube passed through the mouth or nostril into the trachea. The pharynx is packed to prevent inhalation of air around the tube and to catch all extraneous matter that may fall toward the trachea. Nasal administration should be used whenever practicable, i. e., for the more simple operations where extraneous matter is not likely to fall into the trachea; the intracheal method in all other cases. Insufflation is not recommended. Preoperative treatment is advisable when the patient can recover in bed, in order to alleviate his natural fears and to make the anesthetic more pleasant for him to take, easier to administer and smoother in effect. If the patient has been properly prepared, there is no need to add any other anesthetic agent to the gas and oxygen mixture.

Radiation Therapy in Cancer of the Mouth: The authors, G. E. Pfahler and J. H. Vastine (*J. A. M. A.*, Feb. 28, 1931), have found that by increase of filtration and prolongation of application, the end-results of irradiation are much more satisfactory than those of electrocoagulation, insertion of radium needles and combinations of these procedures with surgery; suffering and distress being also minimized. The radium element is applied locally in the mouth with a filtration of at least 1 mm. of platinum and of 2 mm. when the space will permit. In virtually all cases, the local growth disappears, without mutilation of the normal tissues. The lesion must be attacked from as many angles as possible, at a distance of from 3 to 6 mm. The effect must be continued for over three weeks, or until the local mucous membrane becomes white or desquamates. The normal tissue is protected by lead covered with rubber. Areas previously treated must be excised or radium needles inserted. Tobacco in any form is prohibited. Roentgen-ray examination of the alveolar process and teeth should be made and all diseased teeth removed. The mouth must be kept clean. Wassermann tests and blood counts are an important part of the progressive care of the case. The nourishment of the patient is important to maintain vitality at a good level. Among the advantages of treatment by pure gamma radiation is painless application, no mutilation or constitutional symptoms or skin effects of any consequence and disappearance of metastatic lymph nodes. Anesthetization and hospitalization are unnecessary, and the function of the tongue is preserved. The treatment is expensive, and experience on the part of the physician in handling it to good advantage is necessary. The occupation of the patient is interfered with for at least a month, and the case must have the constant supervision of an experienced radiologist. The patient must cooperate constantly and must neither interrupt the treatment nor consider himself cured prematurely. The authors have treated 111 cases of intra-oral cancer by this method in the last six years. Thirty-nine patients have recovered and nineteen under treatment are expected to recover. Treatment was interrupted in four cases, five patients cannot be traced and forty-four are dead. It is the belief of the authors that 75 per cent of patients should recover if application for treatment is made earlier than is usually the case and the case is skilfully treated by the method described.

Medical Means of Ensuring a Normal Dentition: In considering all possible causes of caries, L. G. Housden (*Brit. Dent. J.*, Dec. 15, 1930) first discusses heredity. This he does not believe has anything to do with the quality of the teeth; nor does he believe that prenatal conditions affect the child's teeth. Coming to the postnatal period, he considers first of all the important question of diet, both from its influence on metabolism and from its mechanical and chemical actions in the mouth. The author quotes the dietary discoveries of Drain, Boyd and Nelson in regard to feeding several diabetic children and several suffering from celiac disease, but calls attention to the fact that while caries into the dentin was checked on these corrective diets, there is no evidence that the primary attack on the enamel would not have occurred even under this dietary régime. As evidence that diet is important in formation of tooth structure, the author quotes the instance of a family in which the mother and her two sons had excellent teeth and the only daughter had poor teeth. All three children had been breast fed, but the daughter had been inadequately fed thereafter because of poor appetite. The statement of J. Sim Wallace that the cause of caries is carbohydrate stasis is questioned in view of the fact that some teeth are decayed when they erupt. The author states that whether it is true that enamel does contain a small percentage of organic matter, and is

thus somewhat affected by metabolism, all will agree on the wisdom of preventing food from caking around the teeth. Hygiene is next considered. On the unscientific but well demonstrated principle that the healthier the body generally the sounder the various parts of that body, the provision of fresh air and sunshine may be said to be one of the methods of insuring a normal dentition. The use of hard foods from the time of weaning the infant is advocated, and thumb sucking is discouraged from its inception. Cod liver oil, the mercury vapor lamp and diets containing milk, whole wheat bread, butter, eggs, fruit and vegetables, meat and fish being secondary in importance, are means to better dentition. The use of fruits, the author believes, on the principle that an "apple a day keeps the doctor away," will keep not only the doctor but also the dentist away.

Shock and Collapse: As a fourth chapter of a discussion of the principles of preoperative and postoperative treatment, Reginald A. Cutting (*Am. J. Surg.*, February, 1931) discusses shock and collapse, the latter term being loosely applied to the more severe degrees of shock, associated with marked depression. Shock, which is characterized by fall in blood pressure, decrease in pulse pressure, subnormal temperature and rapid shallow respiration, is classed as primary or secondary. In primary shock, an injured person may be affected largely mentally by his attitude toward his injury, or the condition may be the result of a violent emotion. Primary shock is particularly prone to occur under the influence of hunger and exposure. Secondary shock may occur as a result of prolonged operation or serious accident, hemorrhage, rough manipulation of the viscera and the absorption of toxins, especially after abdominal operations on patients with suppurative peritonitis. As regards the mechanism of shock, the only essential physiologic phenomenon which has been demonstrated is deficiency of the volume of blood in actual circulation. In the terminal stage of shock, the patient shows a profound apathetic mental reaction; in mild shock, the circulatory system alone may be affected, the mental reactions being unusually alert. Rough handling of tissues, sepsis, the use of strong antiseptics, undue exposure of tissue to the air, and tissue drying, loss of fluids, especially blood, loss of body heat, fatigue, excitement and starvation, must all be avoided if shock is to be successfully averted. In mild cases of shock, copious quantities of water taken by mouth or by rectum may restore the blood volume. Water thus taken is slow in being taken up by the circulation; therefore, in well established shock, fluid must be introduced directly into the vascular tree, blood alone affording any permanent improvement, as other artificially compounded solutions diffuse into the tissues as fast as they are introduced into the blood stream. An acacia gum-saline solution has some enthusiastic advocates, who regard the failure of this compound in the hands of others as merely an indication of carelessness in preparation of the solution or in the technic employed. Blood transfusion, although specific in cases of shock due to hemorrhage, in other cases of shock is of questionable efficacy. Early hot saline infusions are of greater value than delayed blood transfusion, because the fundamental aim of the treatment of shock is preventive. When recognized early, shock readily yields to ordinary supportive treatment; when it is recognized late and in its firmly established form, any and all kinds of treatment will probably fail. One of the most important considerations in the treatment of shock is the maintenance of the body heat. This may be accomplished by the application of external heat, by hot drinks, by hot infusions and by means of diathermy, which is regarded by some surgeons as one of the most potent factors in the treatment of shock and hemorrhage. Of the drugs, morphin alone has value through its sedative influence, which far outweighs its possible depressant physical action. Cardiac or respiratory stimulants are virtually without value as the conditions that they would aim to treat are due to circulatory deficiency. Animal experimentation has shown that epinephrin is ineffective in raising the blood pressure in hemorrhage or after prolonged anesthesia unless given in quantities, and even then the effect is for a brief period, followed by greater depression. Ephedrin may raise the blood pressure for a longer period, but cardiac failure may result. Pituitrin is of even less value than epinephrin in its vasoconstrictor effects. Experimentation has proved that caffein, camphor and strychnin, drugs formerly enjoying favor in treatment of vascular depression, are worthless in this respect. Alpha-lobeline gained a foothold in the treatment of depression because certain experimenters found that its administration lead to excitation in ani-

mals in some stages of depression of the respiratory center induced by urethane, morphin and chloral hydrate administration. More critical studies have shown that in profound depression, in various animals, excitation was slight or absent, or depression was even increased, in some cases to the point of fatality.

MISCELLANY

BOOK REVIEWS

Applied Orthodontia. An Introductory Text for Students and Practitioners of Dentistry. By James David McCoy, M.S., D.D.S., F.A.C.D., Professor of Orthodontia in the College of Dentistry, University of Southern California, Los Angeles, Calif. Third edition, thoroughly revised; illustrated with 239 engravings; 344 pages; price, $4.50. Published by Lea & Febiger, Philadelphia.

This standard work needs little in the way of detailed review. Dr. McCoy has so firmly established himself not only in orthodontic practice but also as an author that anything which emanates from his pen carries with it the stamp of approval.

In this third edition, the author has availed himself of the opportunity to thoroughly revise his work, and one of his characteristics relates to his willingness to advance with the times even though in so doing he finds himself obliged to scrap some of his preconceived ideas.

His treatment of the subject is always characterized by a sane conservatism, and yet he readily grasps the salient features of any real advance and is always willing to profit by it.

The publishers have turned out a splendid piece of work in the printer's art, and the book as a whole is worthy of all commendation.

Office Accounting and Record System for Dentists. By John F. Christiansen, M.S., D.D.S., Department of Dental Economics, College of Dentistry, University of Southern California.

It has been the aim of the author to make this system as comprehensive and as simple as possible. It embraces every conceivable operation and all possible records. While prepared primarily for dental students, it may be used by practicing dentists as well, and the system once installed may be made available for every economic requirement.

The growing necessity for a complete system of records and accounting in dental practice must make its appeal to every forward-looking man and woman in the profession, and Dr. Christiansen has studied his system so thoroughly that all of those who enter practice should feel under obligation to him for his contribution to the practical needs of the day.

The Vitamins. By H. C. Sherman, Mitchell Professor of Chemistry, Columbia University, and S. L. Smith, Senior Chemist, Office of Experiment Stations, United States Department of Agriculture. American Chemical Society Monograph Series; second edition; 575 pages; price, $6.00. Published by the Book Department, The Chemical Catalog Company, Inc., New York City, 1931.

If there is one topic that has been mentioned more than any other on the subject of nutrition it is that of vitamins. While little or nothing is known about the chemical nature of vitamins, there is a constant study being made of the subject and an increasing knowledge of the rôles the vitamins play in the life processes. This book is really a series of monographs, and the treatment is not confined strictly to the consideration of the chemistry of vitamins, but in view of the practical needs of the day, there is interwoven with the text much of the physiologic, the pathologic and the nutritional aspects of the subject, which, after all, make the greatest appeal to the average reader.

The feature of greatest value to many students of the subject is the very extensive bibliography. When we consider that there are more than 180 pages of bibliography, it must be realized that the references are most comprehensive and of the greatest interest. No student of vitamins can afford to be without this book.

Procedures in Modern Crown and Bridgework. The Principles and Technique of Stationary and Removable Bridges. By Lee Walter Doxtater, D.D.S., New York City,

New York, Professor of Crown and Bridge Prosthesis, Dental School of New York University. Illustrated with 577 engravings, presenting sequentially every essential detail of the technics described, thus creating a practical textbook for the graduate student as well as the undergraduate student. 473 pages; price, $8.00. Published by Dental Items of Interest Publishing Company, Inc., Brooklyn, N. Y.

The subject of crown and bridge work maintains its almost universal interest for the dental profession. The question always arises as to the choice between fixed and removable bridges, and each type has its advocates, but the author of this book very wisely considers both methods and studies the qualifications and limitations of each.

It would seem that every conceivable approach to the subject of bridgework had been made in this volume, even in such allied subjects as pulp canal work and local anesthesia. A notable chapter has been given to the porcelain jacket crown, and this beautiful type of restoration is worthy of all consideration owing to the growing interest in it and the artistic results that may be obtained with it.

In the science and art of restorative work, where teeth have been lost, there is no end to the possibilities of bridgework of the various kinds, provided a sufficient number of teeth have been retained to furnish adequate anchorage.

Therefore, the profession needs all the literature possible on this subject and the present volume will prove to be a very worthy contribution to add to those that have preceded it by other authors.

The text and illustrative matter are worthy of the best traditions of the publishers, and the volume as a whole is a credit to all concerned.

REVISED PROHIBITION REGULATIONS, PERMITTING DENTISTS TO WITHDRAW INTOXICATING LIQUORS, EFFECTIVE AS OF APRIL 1, 1931

By HOMER C. BROWN,* D.D.S., Columbus, Ohio

The House of Delegates of the American Dental Association, by resolution adopted July 24, 1930, instructed "its Committee on Legislation at its first opportunity to endeavor by every honorable means at its command to correct this unjust and discriminating ruling of the Federal Government, depriving dentists of the use of whiskey and brandy in office practice for direct administration."

In harmony with this resolution, we conferred with J. M. Doran, commissioner of industrial alcohol, Sept. 27, 1930 and, under date of October 9, we wrote the Secretary of the Treasury and the Attorney General incorporating the resolution and supplementing other specific data relating to the problem. In the latter part of November, we again conferred with Dr. Doran, Colonel Woodcock and Mr. Youngquist. We held subsequent conferences the third week of February, and aggressively followed this matter up from time to time. At first, it was generally understood that the revised regulations would be approved about the middle of December, to go into effect January 1, but various postponements delayed this until April 1.

Dr. Doran, Colonel Woodcock and Mr. Youngquist were very courteous throughout these developments, but it was necessary to stress and restress, from time to time, the need for granting the dentist this withdrawal privilege. The complete revised regulations are not available for thorough checking, but we are advised that dentists have equal privileges with physicians in obtaining alcohol and intoxicating liquors, that is, 2 gallons of alcohol and 6 quarts of whiskey or brandy. We are further informed that the quantity of alcohol may be increased on the presentation of satisfactory evidence that the amount is not sufficient to meet the legitimate professional requirements of the individual practitioner.

The following circular letter from Dr. Doran is incorporated for your specific information:

"Circular Letter No. 58
April 1, 1931.

"To Supervisors of Permits,
and Others Concerned:

"Section 1731, Regulations 2, Revised April 1, 1931, provides as follows:

"Sec. 1731. Liquor administered by dentists.—Intoxicating liquor may be administered by a dentist to his patients while under his immediate care in cases in which the use of such liquor is necessary to afford relief. A dentist may under proper permit obtain not more than 6 quarts of liquor during any calendar year for administering to patients.

*Chairman, Committee on Dental Legislation, American Dental Association.

Liquor administered by dentists as herein provided may not be furnished to any person other than the patient, and may not be furnished to the patient under conditions constituting a sale.

"Dentists holding permits to use alcohol, who intend to administer liquor to patients under the above quoted Section in the present calendar year, will be required to make application for amendment of their basic permits. Permits to purchase may not be issued until the liquor applied for is covered by the amended basic permit.

"Permits to purchase will be issued for the quantity authorized under Section 1731 for a calendar year. The quantity so obtained will be in fact for a full calendar year. If the permit to purchase is issued on May 1, 1931, no further purchase may be made until May 1, 1932.

(Signed) J. M. DORAN,
Commissioner."

As explanatory to the foregoing, I will say that there has been more or less criticism directed against our Committee, and organized dentistry in general, for not fully safeguarding the interest of the profession at the time of the passage of the Volstead Act. It is a matter of record that I resigned as a member of the Committee on Dental Legislation at the 1918 Annual Session held in Chicago, but was reelected at the New Orleans meeting in 1919, and the Volstead Act was passed during that interim. This is not intended as an alibi, but rather as a statement of fact. However, I do not believe that the Committee on Dental Legislation, or the united dental profession, could have convinced Congress that dentists should be authorized to write prescriptions for whiskey or brandy the same as physicians. Further, only a very small percentage of our members think they should be permitted to write such prescriptions while another limited group do not approve of the withdrawal privilege which has just been granted. On the other hand, the great majority recognize the need of whiskey and brandy for direct administration in office practice and feel that it is a decided handicap and discrimination not to be privileged to use anything which they may consider necessary and, at the same time, they object to any group telling them what they can or cannot employ in conducting a professional practice. Therefore, I take pleasure in setting forth the foregoing.

CORRESPONDENCE

STATE OR SOCIALIZED (PANHANDLE) MEDICINE

To the Editor:

It seems to have become the fashion of late for the so-called political economists, and others who deem themselves to be of the intelligensia, to speak and to write of state or "panel" medicine and "panel" dentistry.

Superficially, this presents a fine idea, but will some advocate please take the time to explain to the rest of us, who will gladly be considered simple, if you call us practical, men, what this "panel" would require of the dental surgeons? What professional responsibilities to the public? What to the state?

We practical simpletons would have him answer many little questions such as the following: How will the "panel" handle the thousands of Johns Doe who never take thought to oral or personal hygiene of any sort? Will the state continue to treat him the while he disintegrates; or is it proposed to have a corps of "panel" toothbrushers to follow the milkman? And of course the state will at the same time furnish "socialized" toothbrushes, and "panel" toothpaste, and warm running water for each and every one of us.

There are so many, many things that we should like to know about it; such a grand idea—so bureaucratico-socialistico.

And it calls up such a wealth of new ideas and plans. Now that is the fortunate way such schemes have of working out; each one, on its occurrence, calling up at least three new ones, so that the author is kept harmlessly chasing from one idea to another in an ever widening circle until the original plan is lost sight of.

To get back to panels. The "panel" advocates have omitted a "panelette," thereby looking to deprive some relatives, perhaps, of this proposed treatment; if, as, and when, administered. So here's to the veterinary "panel." May its future be brightly painted, or highly polished. And when the mules shall have become extinct, let us duco the automobile "panel." By such time, it may well be imagined that the pink "panel" of today's proposal will have intensified to a terrible red.

A member of the legal fraternity has recently stated that the dental profession should

provide for "every one in the State, the best service at a cost which he can individually bear." Now were some dental surgeon to inform him that the legal profession is as fully obligated, collectively, and individually to serve the public with the law, he would probably be amazed. To such as him, the Great Healer was speaking when He said, "Cast first the beam out of thine own eye and then shalt thou see clearly to pull out the mote that is in thy brother's eye."

Only we who spend the hours daily in our clinics are capable of viewing this picture of the oral health of the state. It is a picture of complexities which have their inception in ignorance, vicissitude and inherent infirmity. No men can be more mindful of, or more grieved by, the sufferings of neglected human beings, than we who read so much of life histories as recorded by these sufferings.

Doctors of dentistry are justly proud of their accomplishments along the way in which we have all advanced, and are steadily moving forward with their labors and educational propaganda.

But the idea implied, that all men ever can be equal physically this side of Heaven, is only a chimera.

W. B. Stewart, D.D.S.,
35 Sixth Avenue,
Long Branch, N. J.

March 18, 1931.

NEWS

Dr. Byrnes Made Dean: Ralph R. Byrnes, formerly executive dean of the Atlanta-Southern Dental College, has been made dean, succeeding the late Dr. Thomas P. Hinman. Dr. Byrnes has been connected with the college since 1920, when he was called from the Medical College of Virginia, where he held an executive position, to fill the position of vice dean and superintendent of the Atlanta institution.

Dr. Gies Made Honorary Member of Allied Dental Council: At a recent meeting of the Allied Dental Council, William J. Gies, M.S., Sc.D., LL.D., Ph.D., professor of biologic chemistry at the College of Physicians and Surgeons, Columbia University, was presented with a testimonial and elected an honorary member of the council, in recognition of his services to the dental profession. Since 1909, Dr. Gies has carried on investigations along the lines of dental education, making numerous suggestions for the revision of dental school curriculums. Dr. Gottlieb, histologist, of Vienna, is the only other honorary member of the Allied Dental College.

Joseph Samuels Dental Clinic Dedicated: The Joseph Samuels Dental Clinic for Children of the Rhode Island Hospital, Providence, was dedicated, March 18. The clinic building, a two-story structure, is equipped to meet the exacting requirements of modern dental practice and is so constructed that it can be enlarged at any time to meet the growing needs of the community. The building is connected by a corridor with the out-patient department of the Rhode Island Hospital. The donor, Col. Joseph Samuels, was honored by a banquet following the dedicatory service. Five hundred guests, citizens of Providence and members of the medical and dental professions, attended the testimonial dinner. In recognition of his gift to the city and the dental profession, Colonel Samuels was presented with the 1931 scroll and medal of the Rhode Island Dental Society, an honor bestowed each year for distinguished services to dentistry.

A Needed Advance: In order to correct a reported lack of instruction in dental pathology in medical schools, the Medical Department of the University of Oregon is inaugurating a movement that will be far-reaching in its effect. For the past six years, didactic lectures have been given to senior students on oral pathology, and now a more intimate tie-up is to be established by the appointment of a dental intern for the hospitals with a staff of six visiting consultant dentists whose work will be in clinical demonstrations on patients in the out-patient clinic for senior medical students. These men will occupy positions similar to clinical instructors in the medical school on other subjects, such as eye, ear, nose and throat. This activity has for its purpose instruction of medical students in dental problems. The credit for initiating this movement is given to Arthur W. Chance of Portland, who has devoted much energy to its consummation.

ASSOCIATION NEWS

At Home

The central offices are now located at 212 East Superior Street and a cordial invitation is extended to visit your new home.

A. D. A. Group Insurance

The following claims were paid during March, 1931:

Clyde U. Mayfield, Pine Bluff, Ark.	$ 3,000
Paul A. Hielscher, Chicago, Ill.	3,000
Claude A. Schumaker, Albuquerque N. M.	3,000
John R. Davis, Lincoln, Nebr.	3,000
Joseph P. Meehan, New Britain, Conn.	3,000
Luther Thomas Lundy, Taylorville, Ill.	3,000
Charles Wilton Howgate, Greenwich, Conn.	1,000
August Meyer Ericson, Hector, Minn.	3,000
	$22,000

Total claims paid to March 31, 1931, 68.
Amount, $174,000.00.
Total certificates, 9,499.

A Reliable Buyers' Guide

The endeavor to present reliable products to the membership through the advertising pages of The Journal necessitates the refusal of thousands of dollars worth of advertising copy annually. This service, together with other information published in The Journal, should enable a member to make intelligent selections, which should be beneficial to his practice and necessarily to his patients, and thereby furnish recognition to the manufacturer and dealer who is able to meet the standard required.

Foreign Interest in The Journal

An analysis of the subscriptions to The Journal shows a remarkable interest from foreign countries. Paid subscriptions totaling 746 indicate the desire on the part of leaders of the dental profession in other countries to avail themselves of the opportunity of receiving the latest and best dental literature from the United States. The following tabulation shows in detail how well The Journal covers the world:

Argentine	4
Australia	56
Austria	7
Bahamas	1
Belgium	2
Bermuda	1
Brazil	2
Bulgaria	1
Burma	1
Canada	283
Ceylon	2
Chile	3
China	8
Colombia	1
Cuba	2
Czechoslovakia	2
Denmark	2
Egypt	1
England	18
Ecuador	1
Finland	1
France	10
Germany	19
Greece	2
Guatemala	2
Holland	4
Hungary	2
India	3
Ireland	1
Italy	6
Japan	137
Java	1
Korea	1
Mexico	9
Netherlands	6
Newfoundland	2
New Zealand	63
Norway	5
Palestine	1
Peru	1
Poland	1
Portugal	1
Russia	9
Scotland	5
South Africa	1
Spain	5
Sweden	33
Switzerland	5
Syria	4
Uruguay	8

ANNOUNCEMENTS*

CALENDAR OF MEETINGS

American Dental Association, Memphis, Tenn., Oct. 19-23, 1931.

American Dental Hygienists' Association, Memphis, Tenn., Oct. 19-23, 1931.

American Dental Society of Europe, Paris, France, July 29-August 1, 1931.

American Society of Oral Surgeons and Exodontists, Memphis, Tenn., Oct. 16-17, 1931.

International Dental Congress, Paris, France, Aug. 3-8, 1931.

International Orthodontic Congress, London, July 20-24, 1931.

International Stomatologic Congress, Budapest, Sept. 2-7, 1931.

Ontario Dental Association, Toronto, May 26-29.

Committee on Costs of Medical Care, Washington, D. C., September 17-24.

Northern Ohio Dental Association, Cleveland, June 1-4.

Society for Advancement of General Anesthesia in Dentistry, New York City, third Monday in February, April, October and December.

Upper Peninsula Dental Society, Iron River, Mich., June 25-27.

STATE SOCIETIES

District of Columbia, at George Washington University, Washington, D. C., second and fourth Tuesdays in each month from October to June, inclusive.

May

Illinois, at Peoria (12-14).
Indiana, at Indianapolis (18-20).
Iowa, at Des Moines (5-7).
Maryland, at Baltimore (4-6).
Massachusetts, at Boston (4-7).
Missouri, at Kansas City (25-29).
Nebraska, at Omaha (18-21).
New York, at New York City (12-15).
North Carolina, at Winston-Salem (4-6).
North Dakota, at Fargo (12-14).
Pennsylvania, at Pittsburgh (5-7).
South Carolina, at Columbia (11-12).
South Dakota, at Huron (11-12).
Texas, at Houston (12-15).
Vermont, at Burlington (20-22).
Virginia, at Old Point Comfort (11-13).
West Virginia, at Huntington (18-20).

June

Arkansas, at Little Rock (1-3).
California Southern, at Los Angeles (8-13).
Georgia, at Atlanta (10-12).
Maine, at South Poland (18-20).
Mississippi, at Gulfport (4-6).
Nevada, at Reno (6).
Oregon, at Portland (17-20).
Washington, at Bellingham (June 30-July 1).
Wisconsin, at Milwaukee (9-11).
Wyoming, at Sheridan (22-23).

December

Ohio, at Cincinnati (1-3).

MEETINGS OF STATE BOARDS OF DENTAL EXAMINERS

Alabama, at Birmingham, June 22. E. W. Patton, Secretary, 1807 Comer Bldg., Birmingham.

Arkansas, at Little Rock, June 22-25. Clarence W. Koch, Secretary, 817 Donaghey Bldg., Little Rock.

California, at San Francisco, May 23; at Los Angeles, June 20. Bert Boyd, Secretary, 610 S. Broadway, Los Angeles.

Colorado, at Denver, June 2-6. Z. T. Roberts, Secretary, 810 Metropolitan Bldg., Denver.

Connecticut, at Hartford, June 24-27. A. J. Cutting, Recorder, Southington.

Delaware, at Wilmington, June 17-18. W. S. P. Combs, Secretary, Middletown.

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*Announcements must be received by the fifth day of the month in order to be published in the forthcoming issue of THE JOURNAL.

Iowa, at Iowa City, May 25-28. Hardy F. Pool, Secretary, Mason City.

Indiana, at Indianapolis, June 15. J. M. Hale, Secretary, Mt. Vernon.

Kentucky, at Louisville, June 5-10. Robert L. Sprau, Secretary, 970 Baxter Ave., Louisville.

Maine, at Augusta, June 22-24. Alton H. Swett, Secretary, 192 State St., Portland.

Massachusetts, at Boston, June 10-13. W. Henry Grant, Secretary, State House, Boston.

Minnesota, at Minneapolis, June 12-20. Walter H. Smith, Secretary, 2337 Central Ave., Minneapolis.

Mississippi, at Jackson, June 16. T. Ford Leggett, Secretary, Laurel.

Montana, at Helena, July 14-18. T. P. Regan, Secretary, Helena.

Nebraska, at Omaha (June 15-17) and Lincoln (June 18-20). Mrs. Clark Perkins, Director, Bureau of Examining Boards, Dept. of Public Welfare, Lincoln.

New Jersey, at Trenton, June 29-July 4. John C. Forsyth, Secretary, 148 W. State St., Trenton.

New Mexico, at Santa Fe, May 27-29. J. J. Clarke, Secretary, Artesia.

Pennsylvania, at Philadelphia and Pittsburgh, June 18-22. W. A. McCready, Secretary, 115 Highland Bldg., Pittsburgh.

Rhode Island, at Providence, June 22-25. Albert L. Midgley, Secretary, 1108 Union Trust Bldg., Providence.

South Carolina, at Greenville, June 23-25. W. H. Sherard, Secretary, Anderson.

South Dakota, Sioux Falls, June 25-27. John J. Berry, Secretary, Deadwood.

Tennessee, at Memphis, June 8. F. W. Meacham, Secretary, Hamilton National Bank Bldg., Chattanooga.

Vermont, at Montpelier, June 29-July 1. H. B. Small, Secretary, Burlington.

Virginia, at Richmond, June 9. John M. Hughes, Secretary, Medical Arts Building, Richmond.

Wisconsin, at Milwaukee, June 15-19. S. F. Donovan, Secretary, Tomah.

Wyoming, at Cheyenne, June 29-July 1. I. P. Hayes, Secretary, Sheridan.

DELAWARE STATE BOARD OF DENTAL EXAMINERS

The next meeting of the Delaware Board of Dental Examiners will be held in the Municipal Bldg., Tenth and King streets, Wilmington, June 17-18, from 9 a. m. to 5 p. m. For further information, address

W. S. P. Combs, *Secretary*,
Middletown.

STATE OF WYOMING BOARD OF DENTAL EXAMINERS

The State of Wyoming Board of Dental Examiners will meet in Cheyenne, June 29-July 1.

I. P. Hayes, *Sec'y-Treas.*,
Sheridan.

BOARD OF DENTAL EXAMINERS OF ALABAMA

The Board of Dental Examiners of Alabama will hold its annual dental and dental hygienic examination in Birmingham, commencing Monday, June 22. Failure to forward all credentials to the secretary-treasurer's office at least two weeks before the date of examination will bar the applicant from the examination. For further information, address

E. W. Patton, *Sec'y-Treas.*,
1807 Comer Bldg.,
Birmingham.

PENNSYLVANIA STATE BOARD OF DENTAL EXAMINERS

The Pennsylvania State Board of Dental Examiners will hold its next examinations June 18-22, at Philadelphia and Pittsburgh. Applicants should apply to the Department of Public Instruction, Harrisburg, for the necessary blanks, on return of which with fee and photographs at least ten days before the date of examination, instructions regarding examinations will be sent to the applicant.

W. A. McCready, *Secretary*,
1115 Highland Bldg.,
Pittsburgh.

WISCONSIN STATE BOARD OF DENTAL EXAMINERS

The Wisconsin State Board of Dental Examiners will hold its next examination at Marquette University Dental Department,

Milwaukee, June 15-19. For detailed information, apply to

S. F. DONOVAN, *Secretary,*
Tomah.

MONTANA STATE BOARD OF DENTAL EXAMINERS

The next meeting of the Montana State Board of Dental Examiners will be held, July 14-18, at Helena. For further information, address

T. P. REGAN, *Secretary,*
Helena.

TENNESSEE BOARD OF DENTAL EXAMINERS

The Tennessee Board of Dental Examiners will meet at 9 a. m., June 8, in the Dental Department of the University of Tennessee, at Memphis, for the purpose of examining all applicants who present credentials acceptable to the board. Hygienists will also be examined. Credentials must be brought to the meeting for examination by the entire board. Applications should be in the hands of the secretary five days before the board meeting. For application and statement of clinical requirements, address

F. W. MEACHAM, *Sec'y-Treas.,*
Hamilton National Bank Bldg.,
Chattanooga.

BOARD OF DENTAL EXAMINERS OF MISSISSIPPI

Examinations to secure a license to practice dentistry and dental hygiene in Mississippi will be held in Jackson at the Capitol, June 16. All credentials must be in the hands of the secretary at least ten days prior to the date of examination.

T. FORD LEGGETT, *Secretary,*
Laurel.

NEW MEXICO STATE DENTAL BOARD

The next meeting of the New Mexico Board of Dental Examiners will be held at Santa Fe, May 27-29. For further information, address

J. J. CLARKE, *Secretary,*
Artesia.

ARKANSAS STATE BOARD OF DENTAL EXAMINERS

The Arkansas State Board of Dental Examiners will hold its next examination, June 22-25, at the Hotel Marion, Little Rock. Credentials and applications should be in the hands of the secretary at least two weeks prior to date of examination. For further information or application blanks, address

CLARENCE W. KOCH, *Secretary,*
817 Donaghey Bldg.,
Little Rock.

SOUTH DAKOTA STATE BOARD OF DENTAL EXAMINERS

The South Dakota State Board of Dental Examiners will hold its next meeting June 25-27, at the Carpenter Hotel, Sioux Falls. Applications should be in the hands of the secretary at least one week before the meeting.

JOHN J. BERRY, *Secretary,*
Deadwood.

NEBRASKA STATE BOARD OF DENTAL EXAMINERS

The next examination of the Nebraska State Board of Dental Examiners will be June 15-20. The first three days, oral work will be given at the University College of Dentistry, Lincoln and Creighton College of Dentistry, Omaha. The last three days written work will be given at the State House, Lincoln.

MRS. CLARK PERKINS, *Director*
Bureau of Examining Boards,
Dept. of Public Welfare,
Lincoln.

MASSACHUSETTS BOARD OF DENTAL EXAMINERS

The Massachusetts Board of Dental Examiners will hold an examination for registration for both dentists and oral hygienists in the City of Boston, June 10-13. Full information, application blanks, etc., may be secured at the office of the secretary, Room 146, State House, Boston. All applications must be filed at the office of the secretary at least ten days before date set for examination.

W. HENRY GRANT, *Secretary.*

SOUTH CAROLINA STATE BOARD OF DENTAL EXAMINERS

The South Carolina State Board of Dental Examiners will hold its annual meeting at Greenville, at the Imperial Hotel, June 23-25.

For application blanks and instructions, address

W. H. SHERARD, *Sec'y-Treas.*,
Anderson.

RHODE ISLAND BOARD OF REGISTRATION IN DENTISTRY

A meeting of the Rhode Island Board of Registration in Dentistry for the examination of candidates will be held at the State House, Providence, June 23-25, beginning each day at 9 a. m. Candidates shall present to the secretary of this board, at least one week before the examination a written application on a form provided by the board together with the examination fee of $20.

ALBERT L. MIDGELEY, *Secretary*,
1108 Union Trust Bldg.,
Providence.

WYOMING STATE DENTAL SOCIETY

The fifteenth annual meeting of the Wyoming State Dental Society will be held in Sheridan, June 22-23.

E. C. ANDREW, *Secretary*,
Cheyenne.

OHIO STATE DENTAL SOCIETY

The sixty-seventh annual meeting of the Ohio State Dental Society will be held at the Netherland Plaza Hotel, Cincinnati, December 1-3.

EDWARD J. ROCHE, *Chairman*,
Publicity Committee,
453 Doctors Bldg.,
Cincinnati.

SOUTH CAROLINA STATE DENTAL ASSOCIATION

(Change of date)

The sixty-first annual meeting of the South Carolina State Dental Association will be held in Columbia, May 11-12, instead of May 7-8.

N. W. MACAULAY, *Secretary*,
Medical Bldg.,
Columbia.

GEORGIA STATE DENTAL SOCIETY

The Georgia State Dental Society will be held at the Biltmore Hotel, Atlanta, June 10-12.

G. A. MITCHELL, *Secretary*,
Candler Bldg.,
Atlanta.

TENNESSEE STATE DENTAL ASSOCIATION

Since the American Dental Association is meeting this year in Memphis, the officials of the Tennessee State Dental Association decided not to hold the annual meeting, which was to have been held the last week in April. This action was taken in order to give more support to the A. D. A. meeting. A business session of the state association will be held in Memphis, Monday, October 19.

R. P. Moss, *Secretary*,
Kingsport.

ALPHA OMEGA FRATERNITY

The second annual Midwestern Conference of the Alpha Omega Fraternity will be held in Chicago at the Edgewater Beach Hotel, May 30-31. For information, address

M. S. ALTUS,
4206 Broadway,
Chicago, Ill.

MONSON RESEARCH AND CLINIC CLUB

The annual meeting and clinic of the Monson Research and Clinic Club will be held in St. Paul, Minn., May 21-23, at the Saint Paul Hotel. This meeting will be devoted to the subject of occlusion and its application to the various branches of dentistry. A testimonial banquet will be given to Dr. Monson. For further particulars, address

M. G. WALLS, *Secretary*,
828 Lowry Medical Arts Bldg.,
St. Paul, Minn.

AMERICAN DENTAL ASSOCIATION

Memphis, Tennessee. October 19-23, 1931.

HOTEL RESERVATION

In securing hotel reservations for the 1931 Session, consult the hotel rate-sheet and fill out the blank application below. Mail immediately to the hotel you wish to patronize. The hotel will then advise you of the reservation which has been made for you.

As your first choice may not be available, kindly indicate a second and a third choice. If none of these are available, the hotel manager will mail your application to the Chairman of Halls and Hotels Committee, who will make a reservation for you in as favorable a hotel as possible.

Please remember that a reservation constitutes a contract with the hotel to provide you with the accommodations you desire. If you find it impossible to carry out your part of the contract, namely, to occupy the room at the time agreed on, please write or wire the hotel, releasing it, in order that your room may be available for other members.

MAIL THIS APPLICATION DIRECT TO THE HOTEL

HOTEL RESERVATION

AMERICAN DENTAL ASSOCIATION, MEMPHIS, TENNESSEE, OCTOBER 19-23, 1931

.....Hotel. .....1931.

Memphis, Tenn.

Please reserve sleeping room accommodations as noted below:

.....Room(s) with bath for.....people. Rate desired $..... (per day)

.....Room(s) without bath for.....people. Rate desired $..... (per day)

Second choice hotel.....

Third choice hotel.....

ROOMS TO BE OCCUPIED BY: ADDRESS IN FULL

Applicant..... .....

....

....

Please confirm this reservation to applicant. I further agree to notify the hotel at once in the event I am unable to use this reservation.

IMPORTANT TO HOTEL MANAGER: In the event you cannot accept this reservation, please forward this application at once to Dr. E. F. Simpson, Chairman Halls and Hotels Committee, 735 Sterick Bldg., Memphis, Tenn., who will attend to the assignment of this reservation.

HOTEL	Single Room with Bath	Double Room with Bath	Single Room without Bath	Double Room without Bath
ADLER 73 Linden Ave.	$2.00 & up	$3.50 & up 5.00 & up (twin beds)	$1.50 & up	$2.50 & up
AMBASSADOR 347 S. Main	2.00	3.50	1.50	2.50
CATHOLIC CLUB 185 Adams			1.25	2.00
CHICKASAW 99 S. Main			1.00	1.50
CHISCA 270 S. Main	2.00 & up	4.50 & up 5.00 & up (twin beds)	2.00 & up	3.50 & up
CLARIDGE 109 N. Main	3.00 & up	4.50 & up		
DESOTO 154 E. Calhoun			1.25	2.00
ELK'S 69 Jefferson	3.00-3.50	4.00-5.00 5.00-6.00 (twin beds)	2.00-2.50 Con. bath	3.00-4.00 Con. bath
FOREST PARK 855 Union	2.00	2.50	1.00-1.50	1.50-2.00
GAYOSO 139 S. Main	3.00 & up	5.00 & up	2.00 & up	3.00 & up
HERMITAGE APTS. 200 Union	1.50	2.75	1.00	1.75
WM. LEN 110 Monroe Ave.	2.50 & up	4.50 5.00 (twin beds)		
LONGINOTTI S. Main St.			1.00	1.50
PARKVIEW 1914 Poplar	3.50	5.00-6.00		
PEABODY HOTEL 149 Union	3.50 & up	5.50 & up 7.00 & up (twin beds)		
PLAZA 214 Calhoun	2.00	3.00	1.50-2.00	2.50-3.00
POLK APTS. 630 Madison	2.00	2.50-3.00		
PONTOTOC 69 Pontotoc	1.50	2.00	1.00	1.50
TENNESSEE 80 S. Third St.	2.00 & up	3.00 & up		
WINONA 110 E. Calhoun	2.00	3.00	1.00-1.50	2.00-3.00
WALDORF S .Main St.	1.50	2.00	1.00	1.50

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1930-1931

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